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A STUDY ON THE MAINTENANCE AND SUPERVISION OF THE AIR CLEANING DEVICES AS A STEP TO COUNTER THE ATMOSPHERIC POLLUTION

AIR FILTER SUPERVISION STANDARD COMMITTEE

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3. Study of the effects of atmospheric dust on the performance of the air cleaning devices.

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1. Outline

1-1. Object of the Study

As there are no precise standard specifications regarding the maintenance and supervision of the air cleaning devices provided to the air conditioners installed in the buildings in order to counter the atmospheric pollution, it is very difficult to say that they are maintained properly at present. Although it can be easily imagined that the working life of an air cleaner depends upon the volume of air handled by it and the state of atmospheric pollution, yet no proper investigation has been carried out so far to ascertain the roles the various factors play in shortening its life.

The present study was carried out for the purpose of drawing up a standard for maintenance and supervision of the air cleaning devices on the basis of an investigation of the actual state of their maintenance and supervision in the typical representative buildings in Tokyo. While carrying on the investigation, related experiments were carried out for obtaining the necessary data.

1-2. Scope of the study

The investigation and the experiments covered the following three points.

(1) Investigation of the actual situation prevailing in the maintenance and supervision of the air cleaning devices:

Typical office buildings in Tokyo were selected for the investigation, and the actual state of maintenance and supervision was studied by the members of the team on the spot on the basis of interview with the people in charge. This yielded extremely valuable data.

(2) Test on the effects of the atmospheric dust on the performance of the air cleaning devices:

A number of representative spots were selected in Tokyo, and tests were carried out for determining the variation in the performance of the air cleaning devices in practical use with the passing of time due to the atmospheric dust. These tests were carried out for obtaining the data on the effective life of the air cleaning devices.

(3) Continuous monitoring of the air cleaning devices over a prolonged period:

An appropriate building provided with an air cleaning device was selected here, and the device was operated for a certain stipulated length of time without changing or replacing it for monitoring the variation in the performance of the device over the stipulated length of time. This experiment provided valuable data for drawing up a standard for maintenance and supervision of the air cleaning devices in actual use in the buildings.

1-3. Set-Up of the Study Team

This study was undertaken by the Japan Air Cleaning Association on request from the Ministry of Health, and the team included the following members.

1. M. Fujii, Shibaura Kōgyō Daigaku (Shibaura Industrial University).
2. K. Imano, Kensetsusho Kenchiku Kenkyūjo (Institute of Architecture, Ministry of Construction).
3. H. Yoshizawa, Kokuritsu Koshu Eiseiin (National Public Health Institute).
4. K. Kimura, Rōdō Kagaku Kenkyujo (Labor Science Institute).
5. K. Maekawa, Takenaka Komuten Gijutsu Kenkyūjo (Takenaka Institute of Technology).

2. Investigation of the Actual Conditions Prevailing in the Field of Maintenance and Supervision of the Air Cleaning Devices

2-1. Object of the Investigation

Almost all the air conditioning plants installed in the recently constructed buildings are provided with the air cleaning device. However, points like what types of air cleaning devices are used in these air conditioners and how they are maintained are not very clear. In the present study the above points were investigated in great detail, selecting the relatively new office buildings erected since 1964 for the purpose, for getting a first hand knowledge of the types of the air cleaning devices used at present and the situation prevailing in the field of their maintenance, as it was felt that this would help in pinpointing the actual problems involved.

It was felt that such an investigation would yield valuable data to serve as a basis for drawing up a standard for the air cleaning devices, or for at least formulating a guideline for their maintenance and supervision.

2-2. Methods Employed for Investigation

As stated below, about 50 buildings considered to give a fairly representative cross-section of the recently constructed office buildings were selected, and the details of the air conditioning plant installed, the type of the air cleaning device used, and the state of the maintenance and supervision involving the air cleaning device etc. were discussed directly with the people actually in charge of the air conditioning plants after visiting the buildings.

The points to be covered during the investigation were discussed carefully by the members of the team prior to drawing up the questionnaire form, which was actually filled by the students specializing on air cleaning.

(1) Buildings in which investigation was carried out:

A list was prepared of all the buildings conforming to the conditions specified below, and about 50 buildings were selected at random from among them for the study. Table 2-1 shows the buildings actually selected.

a) The building should be located within the main metropolitan area of Tokyo.

b) The building should be an office building, or a building mainly used as an office.

MAINTENANCE & SUPERVISION OF AIR CLEANING DEVICES

TABLE 2-1

Buildings selected for the investigation

	Name of the Building	Location
1	Nihon Ikueikai Chosha	Shinjuku-ku, Ichigaya, Honmura,42
2	Shakai Bunka Kaikan	Chiyoda-ku, Nagatacho, 1-8-1
3	Fujitagumi Honsha	Shibuya-ku, Sendagaya, 4-6
4	Asahi Biru	Chuo-ku, Ginzanishi, 6-3
5	Isutan Biru	Minato-ku, Nishishinbashi, 2-5-12
6	Tokyo Kotsu Kaikan	Chiyoda-ku, Yurakucho, 2-13
7	Nokyo Biru	Chiyoda-ku, Otemachi, 1-5
8	Tokuei Biru	Minato-ku, Shiba, 5-33-7
9	Juki Mishin Biru	Shinjuku-ku, Kabukicho, 23
10	Taiyo Seimei Honsha Biru	Chuo-ku, Nihonbashi, Edobashi, 2-8
11	Shufu no Tomo Biru	Chiyoda-ku, Kanda, Surugadai, 1-6
12	Toranomon Kinpei Kaikan Biru	Minato-ku, Shiba, Kinpeicho, 1
13	Bansai Birudingu	Chuo-ku, Nihonbashi Dori, 1-6
14	Yasuda Shintaku Jimu Senta	Meguro-ku, Meguro Honcho, 2-25-8
15	Shinjuku Fuji Biru	Shinjuku-ku, Tsunohazu, 1-817
16	Ando Kensetsu Honsha	Chuo-ku, Yaesu, 4-1
17	Teikin Biru	Chuo-ku,Nihonbashi, Horidomecho, 1-11
18	Daiichi Ginko Honten	Chiyoda-ku, Marunouchi, 1-1
19	Komatsu Biru	Minato-ku, Akasaka, 2-3
20	Fuji Ginko Honten	Chiyoda-ku, Otemachi, 1-6-6
21	Kyodo Tsushin Kaikan	Minato-ku, Akasaka, Aoicho, 2
22	Nissho Birujingu	Chuo-ku, Nihonbashi, Edobashi, 1-10

Contd.

AIR FILTER SUPERVISION STANDARD COMMITTEE

	1	2
23	Tokyo Shoken Kaikan	Chuo-ku, Nihonbashi, Kayabacho, 1-14
24	Sumitomo Shoji Kanda Birudingu	Chiyoda-ku, Kanda, Nishikicho, 1-1
25	Shinjuku Biru	Shinjuku-ku, Tsunohazu, 2-8-8
26	Sumitomo, Shinbashi Biru	Minato-ku, Shinbashi, 1-8
27	Tokyo Tatemono Shinmuromachi Birudingu	Chuo-ku, Nihonbashi, Muromachi, 3-3
28	Saiensu Biru	Chiyoda-ku, Nagatacho, 2-5-2
29	Shiseido Honsha Biru	Chuo-ku, Ginza, 7-5-5
30	Nihon Chuo Keibakai Honkan	Minato-ku, Nishishinbashi, 1-1
31	Kanda Tokai Biru	Chiyoda-ku, Kanda, Ogawacho, 1-5
32	Kanto Matsuda Honsha Biru	Itabashi-ku, Oyama, Nishicho, 3-1
33	Shinjuku Toyo Biru	Shinjuku-ku, Tsunohazu, 1-1
34	Tokyo Denryoku Ota Shisha	Ota-ku, Ikegami, 5-12
35	Tokyo Ginko Bunkan	Chuo-ku, Nihonbashi, Honishicho, 1-4
36	Daiichi Ginko Jimu Senta	Shibuya-ku, Shibuya, 2-13
37	Dentsu Honsha Biru	Chuo-ku, Chikuchi 1-11
38	Sanko Biru	Chuo-ku, Chikuchi, 5-6
39	Akai Denki Honsha Biru	Ota-ku, Higashikojitani, 2-12-14
40	Maeda Kensetsu Kogyo Honsha	Chiyoda-ku, Fujimicho, 2-10-26
41	Sanshin Tokyo Biru	Chuo-ku, Hatchobori, 2-3
42	Saegusa Honkan Biru	Chuo-ku, Ginza, 5-10
43	Kasumigaseki Biru	Chiyoda-ku, Kasumigaseki, 3-2
44	Gotanda Daiwa Biru	Shinagawa-ku, Higashi Gotanda, 1-10-11
45	Nakajima Toshoten Honsha Biru	Shibuya-ku, Shibuya, 1-4-13
46	Yoshinaga Purinsu Sogo Biru	Taito-ku, Yanagibashi, 1-4-4
47	Arakawa-ku Chosha	Arakawa-ku, Arakawa, 2-2-3
48	Nihon Seifun Honsha Biru	Shibuya-ku, Sendagaya, 5-27

c) The building should have been built within the period from 1964 to 1969.

d) The floor area should be above 3000 m^2.

e) About 50 buildings should be selected for the study.

f) The buildings which have already been investigated by the Takenaka Komuten Gijutsu Kenkyûjo will be excluded.

(2) Points covered in the investigation and the questionnaire:

The questionnaire used in the investigation has been shown in Table 2-2. The items covered in the questionnaire were the general features of the building, inlet of outside air and the conditions prevailing in its neighborhood, the mode of air conditioning, method of supervision of the machine room, and the air purifying device. Again, the points like the interval of replacing the air cleaning device and its washing etc. were covered through the following questions.

The questions asked about the air cleaning device.

1. On the indoor environment (environment within the ordinary office room).

a) Whether complaints about odor, irritation to the eyes, headache etc. are there?

b) The degree of soiling of the push and pull openings, ceiling, and walls etc.

2. The procedure followed in inspecting the air cleaning device. Whether it is easy?

3. On the regeneration (washing) or replacement of the air cleaning device.

a) On what basis is the time for regeneration or replacement decided?

(i) Periodically (time:); (ii) On the basis of pressure loss ( ) (iii) Whenever the necessity is felt; (iv) No regeneration or replacement is carried out; (v) Others ( ).

b) Time and frequency of regeneration or replacement during the year.

c) Method of washing or changing, the time required and the difficulties involved.

4. Whether the efficiency of the air cleaning device is checked up periodically? If a check up is carried out, then what is the procedure followed?

5. Whether any instruction was imparted at the time of installation? Whether any instruction booklet is there or not.

6. What is the maintenance cost of the air cleaning device? (Breakdown for year and month).

7. What is done with the air conditioning during the intervening period.

8. What other problems are involved in the management of the air cleaning device.

9. The views on the merits and demerits of the air cleaning devices in current use.

10. Other questions.

(3) Time of the Investigation

This investigation was carried out during the period from November 5, 1969 to November 20, 1969.

2-3. Compilation of the Results

Of the various buildings mentioned in Table 2-1, the Gotanda Daiwa Biru shown against Sl. No. 44 was found to be unsuitable for the present study as the floor space of the area accommodating the office was found to be barely 200 m^2. While investigating various points, there were cases where no clear answer could be elicited about the volume of fresh air, cost of maintenance and supervision etc. In such cases the team had to depend on a rough guess work. The results obtained have been compiled in Fig. 2-1 to Fig. 2-9.

2-4. Study of the Compiled Results

(1) General Items

a) Distribution of the buildings according to their gross floor area:

About 40% each of the buildings fell under the gross floor area categories 3000~10000 m^2 and 10000~30000 m^2, the remaining buildings being distributed among the other gross floor area categories.

b) Distribution of persons accommodated in the rooms (Person/unit area)

There is a peak at 0.04~0.06 person/m^2 (35.4%). Considering from the value of 0.083~0.125 persons/m^2 (12 ~ 8 m^2/person) appearing in other documents (investigation carried out by Yoshitake & Togawa; pp. 30, Vol. 6 of Kenchiku Gakkai Shiryōshu), the density appears to be lower in the present cases.

Again, in the Statistic Survey of the Equipment (1965) of the Kenchiku Gakkai (Association of Architecture) the mean density was 0.0636 persons/m^2, a value almost equal to that of the present survey.

c) Relative proportions of the buildings accommodating own office, rented out buildings accommodating tenents' offices and office-cum-shop buildings

TABLE 2-2

Form for Investigating the actual state of installation and maintenance of the air cleaning device

1. General items					
No.	Date of investigation:		Name of the investigator:		
Name of building		Location			
Gross area	m^2	Basic floor area		m^2	
No. of floors	Underground: Above ground:	Tower:	Erection date		
Designer		Constructing firm			
Building owner's representative		Firm installing the air conditioning plant			
	TEL	No. of persons accommodated in the rooms			
Type of building	1. For own use; 2. For renting; 3. Shop cum office.				
2. Inlet for the outside air and the conditions in its vicinity					
Position of the inlet of the outside air					
Relation of the inlet with the chimney, exhausts etc. in the vicinity					
Atmospheric pollution Sources and the state of pollution in the locality					
3. Mode of air conditioning (ordinary office room)					
Mode of air conditioning	1. Single duct method (low speed)	4. A unit at each floor method	7. Fan coil unit method		
	2. Single duct method (high speed)	5. Inducing-type unit method	8. Package and duct method		
	3. Double duct method	6. Radial panel method	9.		
Push opening	1. Anemo 2. Slit 3. Nozzle 4. Universal 5. Pan shaped				
Pull opening	1. Door grill 2. Grill fixed on the wall 3. Ceiling pull				
4. Mode of supervision of the machine room and the personnel					
Supervision under self management	Electrical:	persons	Air conditioning:	persons	Others: persons
Supervision under contractural firm	Electrical:	persons	Air conditioning:	persons	Other's: persons-
	Electrical:	persons	Air conditioning:	persons	Others: persons

5. Air cleaning device (for ordinary office room)

Type 1. Dry type unit 3. Electric dust collector
2. Dry type automatic 4. Others

Name of the air cleaning device Manufacture Model

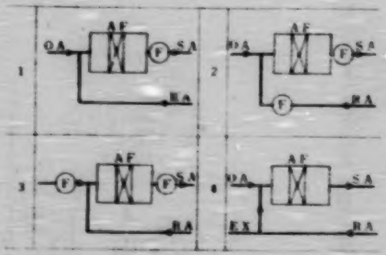
Presence or absence of manometer Type and thickness of filter

Recirculation rate of the air

Duration of operation From (O'clock) to (O'clock)

(1) Which of the following figures give the position of the air cleaning device in the air conditioning system of the building

(2) Any other point which has attracted the attention


1
OA
AF
F
SA
RA
2
OA
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F
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3
F
AF
F
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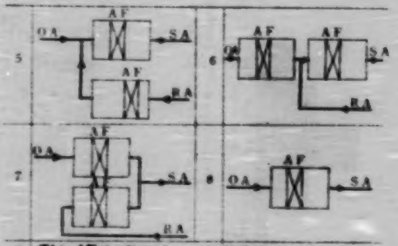
RA
4
OA
AF
SA
EX
RA


5
OA
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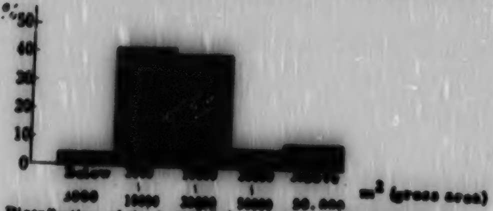
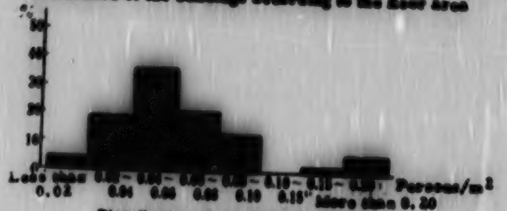
6
OA
AF
AF
SA
RA
7
OA
AF
SA
RA
8
OA
AF
SA

9 The AF is fitted to the indoor unit

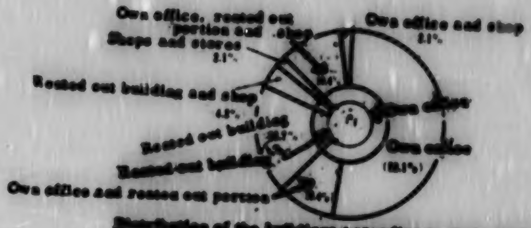
Note: OA: outside air; RA: return air; EX: exhaust
F: fan; SA: supply air; AF: air cleaning device (air filter); AC: air conditioner



Distribution of the buildings according to the floor area

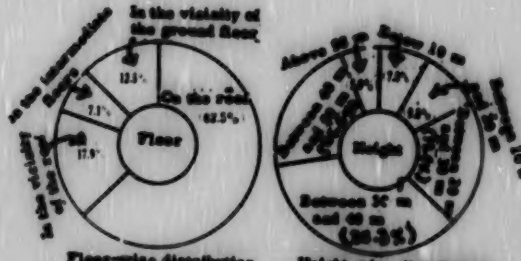


Distribution of the persons working inside the buildings per unit area



Distribution of the buildings according to their mode of use

Fig. 2-1. Buildings where the study was carried out.



Floor-wise distribution
Height-wise distribution

Fig. 2-2. Position of the inlet of the outside air.

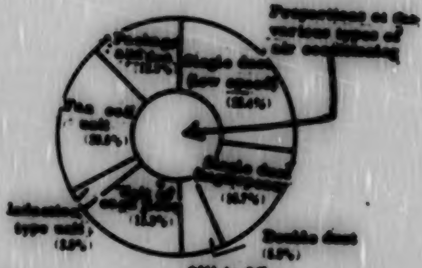
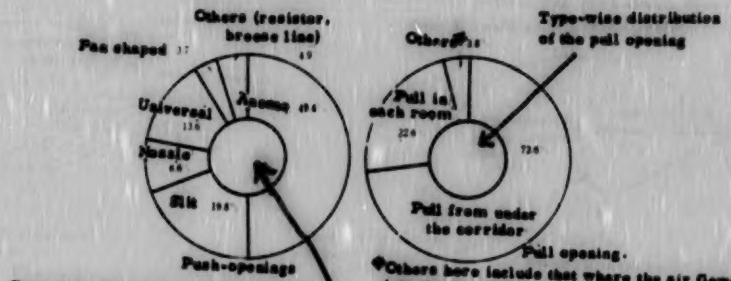


Fig. 2-3. Mode of air conditioning.



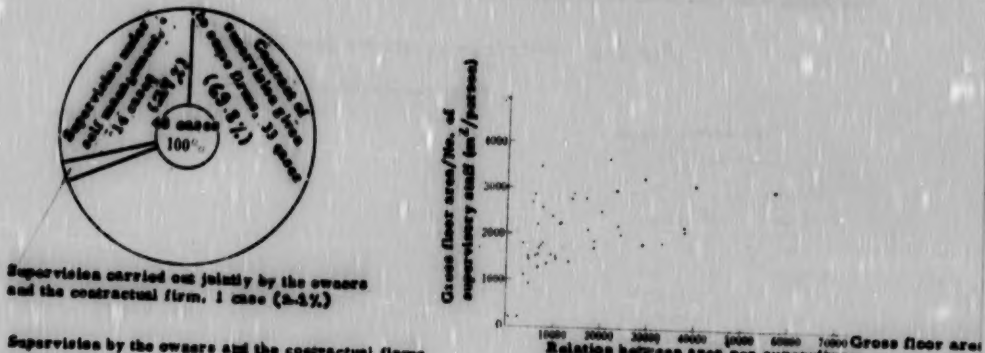
Push-openings

Type-wise distribution of the push opening

Pull opening.

*Others here include that where the air flows directly into the air conditioner after passing under the corridor, and package pull.

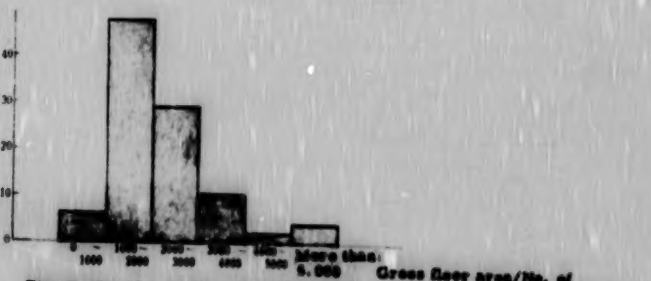
Fig. 2-4. Distribution of the types of the push and pull openings.



Supervision carried out jointly by the owners and the contractual firm, 1 case (2.3%)

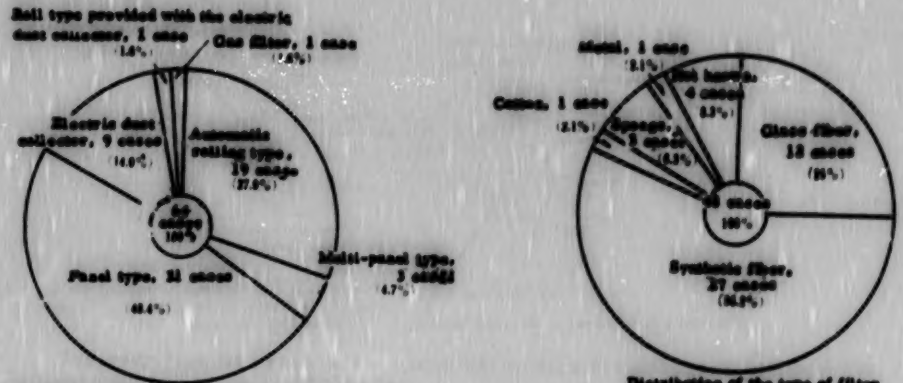
Supervision by the owners and the contractual firms

Relation between area per supervisory staff and the gross floor area



Distribution of area per supervisory staff

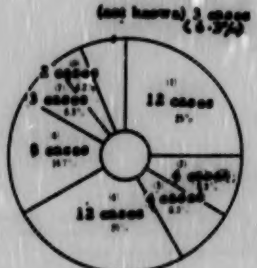
Fig. 2-5. Mode of supervision of the machine.



Distribution of the types of the air cleaning device

Distribution of the type of filter

Fig. 2-6. Air cleaning device (air filter).



Explanatory diagrams

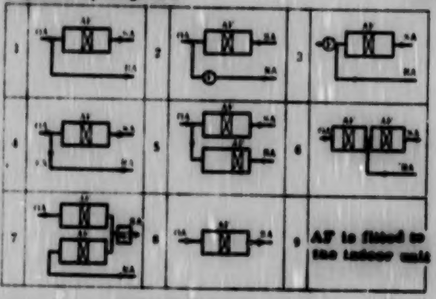
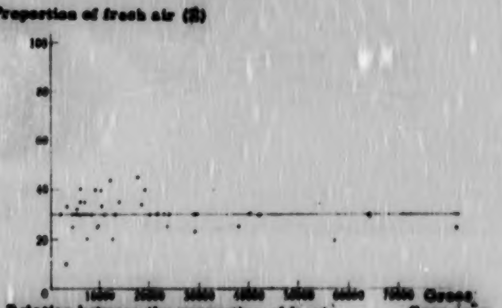
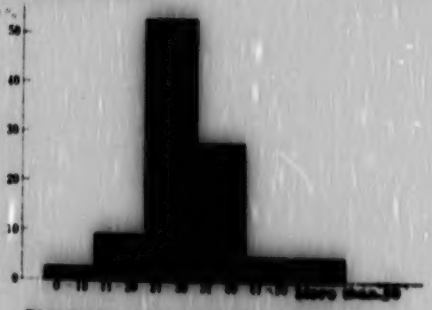

1
2
3
4
5
6
7
8
9
AF
OA
SA
RA
AF is fitted to the indoor unit

Fig. 2-7. Position of installation of the air cleaning device.



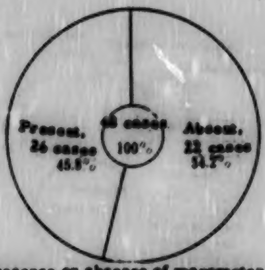
Relation between the proportion of fresh air and the gross floor area



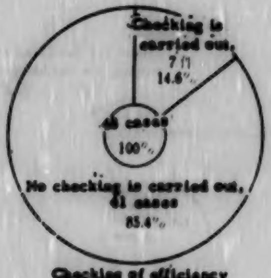
Distribution of the proportion of fresh air

Fig. 2-8. Proportion of fresh air.

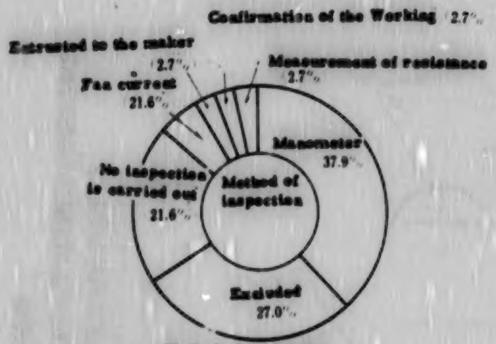
MAINTENANCE & SUPERVISION OF AIR CLEANING DEVICES



Presence or absence of manometer

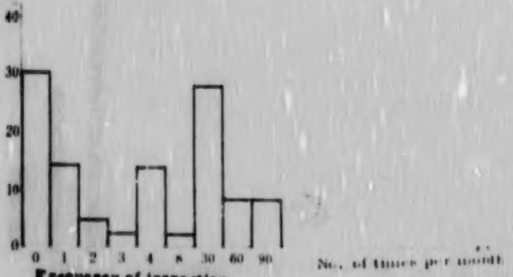


Checking of efficiency



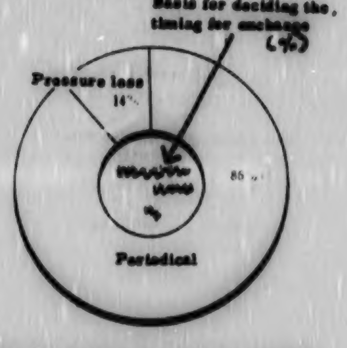
Method of inspection

* Those whose mode of inspection is not known have been lumped together under the heading 'Excluded'

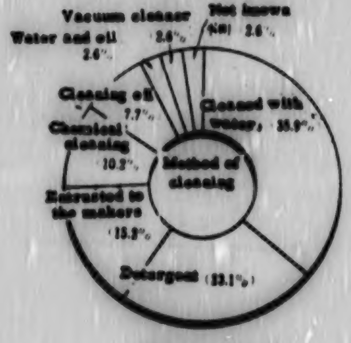


Frequency of inspection

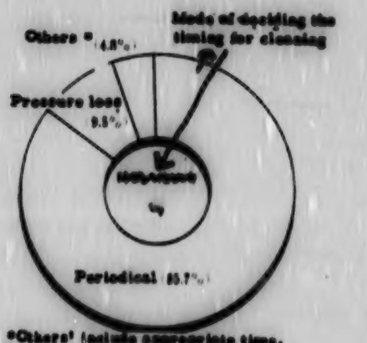
AIR FILTER SUPERVISION STANDARD COMMITTEE



Basis for deciding the timing for exchange

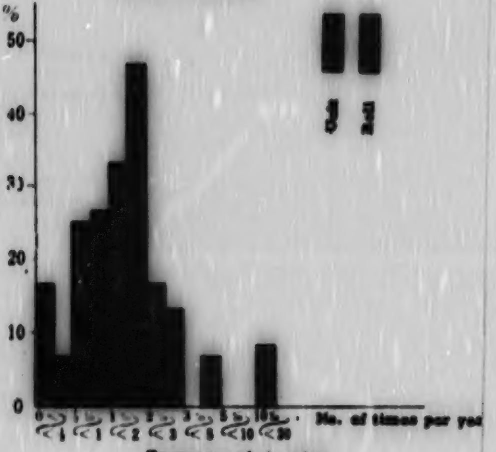


Method of cleaning

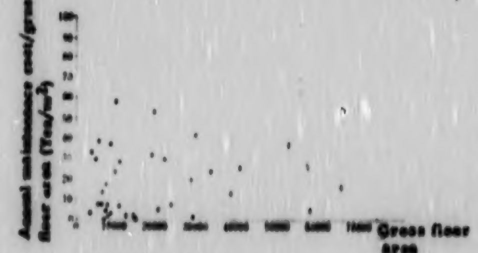


"Others" include appropriate time, time-out and every 14-15 hours etc.

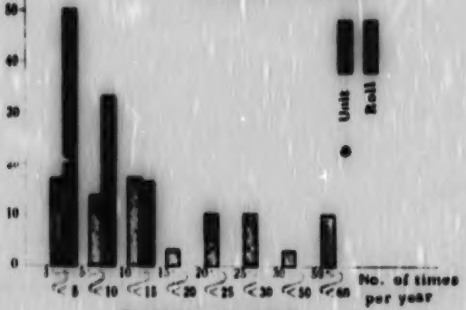
Mode of deciding the timing for cleaning



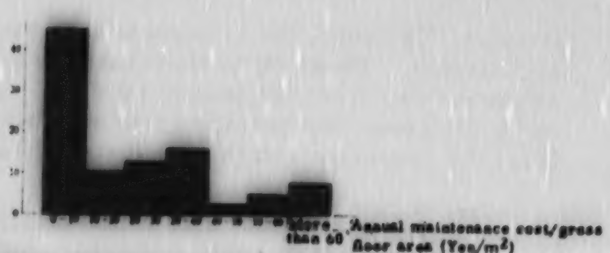
Frequency of changing



Relation between the annual cost per unit area and the gross floor area



Frequency of cleaning



Distribution of the annual maintenance cost per unit floor area

Fig. 2-9. Maintenance and supervision of the air cleaning device.

In the present survey, about 50% of the buildings accommodated the owners' offices, about 20% of the buildings were occupied by offices on payment of rent, and about 20% accommodated offices and shops. As against these figures, the first and the second category buildings represented 43% and 28% respectively in the Statistical Survey of Equipment (1965) of the Association of Architecture.

Thus, the medium and large sized buildings accommodating the office of the owners with relatively large elbow room constituted the principal object of the present study.

(2) Outside Air Inlet and the Conditions in Its Vicinity

a) Position of the outside air inlet

In most of the cases, the outside air inlet was located on the roof (in about 62.5% cases), and the figure jumps up to more than 80% if the inlets located near the top floor are included. When the position of the inlet was seen according to height, most of these (about 35.3%) were found to be located in the height range 30-40 m, and 20% each was located in the 10 m height range above and below the above range, viz. between 20-30 m and between 40-50 m. These figures also testify the location of the inlet near the roof in most of cases.

b) Sources of atmospheric pollution in the locality

In about 87.4% cases, road traffic was cited as the principal source of pollution. As against this, in 4 cases (i.e., 8.3% cases) the factories were mentioned as the source of pollution. These facts show that the buildings studied were situated away from the industrial area. It must be noted that in 16.5% cases the pollution was attributed to the emmissions from the chimneys and the exhausts of the adjacent buildings.

(3) Mode of Air Conditioning (Ordinary Offices)

a) Distribution of the modes of air conditioning (Types 1-9 and mixed types)

Simultaneous use of two or more types has been found to be very common. Individual type-wise speaking, the single duct system was most numerous (above 43%), followed by the fan coil type (about 21%), with the each-floor-unit type coming next in order with about 15%. It must, however, be said that it was difficult to have a very precise picture. When the trend of the different types used was compared with that found in the Association of Architecture Survey mentioned above and that found in the Takenaka Institute of Technology Survey (1968-69), then it will be seen that although the single duct type occupies more or less similar position on the top, yet the use of the fan coil type was found to be slightly higher in the present survey compared to the other two.

b) Types of the principal push opening

The push opening in almost half of the cases was found to be of anaemo type, the slit type coming next with about 20%. The slit type was found to be somewhat higher in proportion here compared to the case of the Association of Architecture Survey.

c) Types of the principal pull opening

In majority of the cases (about 73.6%), the pull was from under the corridor.

(4) Mode of Supervision of the Machine Room

a) Supervision under the owner's management and that entrusted to the contractual firm

The supervision was found to be under the owner's management in 29% cases and was entrusted to the contractual firms in 69% cases. The supervision was carried out jointly by the owners and the contractual firms in the remaining cases. When compared with the findings of the other surveys, the supervision was entrusted to the contractors here in overwhelming number of cases. (Association of Architecture Survey: self management - 59%, contractual firm - 41%; Tekenaka Institute of Technology Survey: self management 63%, contractual firm - 37%).

b) Number of Supervisory Staff

A comparison of the number of the supervisory staff with the gross floor area revealed that there was one supervisory staff per 1000-2000 m^2 gross floor area in most of the cases (48% cases) followed by one supervisory personnel per 2000-3000 m^2 gross floor area (29% cases). Both these percentages are somewhat lower compared to the results of the surveys carried out by Mr. Oshima and by the Takenaka Institute of Technology.

(5) Air Cleaning Device (Air Filter) (For Use in Ordinary Office)

a) Type of the air cleaning device

The penal type accounted for about half (about 48.4%) of the devices, followed by the automatic rolling type and the electric dust collectors accounting for 28% and 14% of the devices respectively. When these were compared with the findings of the other surveys, the predominance of the panel type filter was found to be common in all the cases (48% in the Association of Architecture Survey and 59% in the case of Takenaka Institute of Technology). The multi-panel type was also found to be quite numerous (about 29%) in the Association of Architecture Survey. The multi-panel type filter was found to be relatively rare in the present survey and the survey carried out by Takenaka Institute of Technology (about 5% in both the cases). It seems that the use of this type is showing a trend of decline in the recent years.

b) Type of the filter material

Synthetic fiber was the filter raw material in most of the cases (56%) followed by glass fiber (25%) in the present survey. As against the above findings, the survey carried out by Takenaka Institute of Technology revealed that the synthetic fiber filters were used in 61% cases, whereas the glass fiber filters were used only in 6% cases. The cotton filters, however, were found in about 19% cases.

c) Presence or absence of manometer

The manometer was found installed in relatively higher number of cases (54%).

d) Proportion of fresh air introduced

The proportion of fresh air introduced was found to be around 30% in almost all the buildings.

e) Ventilation system (position of the air cleaning device)

The most simplest types shown in (1) and (4) were found to be provided in the maximum number of cases (about 25% each), followed by the type shown in (6) where the outside air is treated separately (about 17% cases). Not a single system was found to be provided with the type shown in (5). As against these findings, the survey of Takenaka Institute of Technology showed that the total of the types shown in (1) and (4) accounted for 70% of the cases, followed by the types shown in (6) (about 15% cases) and in (5) (about 10% cases).

(6) Questions regarding the Air Cleaning Device

a) Environment inside the room (whether there is any bad smell or irritation etc.)

There was no complaint in as many as 81% of the cases.

b) Soiling of the push opening and the walls etc.

Soiling was noticed in 83% of the cases, of which 15% could be considered to be of the 'very dirty' class.

c) Whether the efficiency of the air cleaning device is checked periodically

Questioning revealed that no checking of the efficiency was done in 85% of the cases. This finding agreed very well with the findings of the Takenaka Institute of Technology.

d) Mode of checking the efficiency

In most of the forms either this item was left blank or 'not known' was entered. Of the seven entries found, the outside agencies were entrusted the job of checking up in two cases.

e) Frequency of inspection of the air cleaning device

No inspection was carried out in the largest number of cases, (about 30% cases), followed by inspection once a day (about 28% cases). Inspection once in a week and once in a month came to about 14% each.

f) Mode of inspection

Inspection was carried out with the help of manometer in about 38% cases, and by 'exclusion method' in about 28% cases.

g) Determining the timing of changing the air filter

The filters were changed periodically in 86% cases, the pressure loss forming the criterion in the remaining 14% cases. In the study conducted by Takenaka Institute of Technology, the filters were found to be changed periodically in about 80% of the cases.

h) Frequency of changing the air filter

In the case of the panel-type and the roll-type filters, the frequency of 1~2 times of changing per year was found in most of the cases followed by 1/2~1 time per year. The frequency of changing the roll-type filter was found to be slightly higher.

i) Method of cleaning the air cleaning device

Water cleaning was carried out in 36% cases, followed by detergent washing in 23% cases. The makers were entrusted the job of cleaning in 15% cases, and the chemicals used as the washing agent coming next with 10% of the cases.

j) Determining the timing of cleaning

Periodic cleaning was carried out in about 86% cases (same as the timing of changing the air filter). The pressure loss was the criterion in about 9.5% cases.

k) Frequency of cleaning

The frequency differed considerably depending upon the panel-type and the roll-type. . In the case of panel-type, the frequency varied over a wide range from 1 to 60 times per year. In the case of the roll-type filters, thq frequency of washing was 1~5 times per year in 50% of the cases, 5~10 times per year in 33% of the cases, and 10~15 times in 17% of the cases.

l) Maintenance cost of the air cleaning device

The value of annual maintenance cost/gross floor area varied over a wide range up to the maximum value of 85 Yen/m^2. However, there were two peeks at 0~10 Yen/m^2 and at 30 Yen/m^2.

3. Study of the Effects of the Atmospheric dust on the Performance of the Air Cleaning Device

3-1. Object of the Test

The object of the test was to obtain data on the behavior of the performance of the air cleaning device of the air conditioner during actual use with the accumulation of atmospheric dust, in order to evolve a basis for maintenance and supervision of the air cleaning device as well as for determining its effective life.

The following points were covered during the test.

(1) The amount of dust captured by the air cleaning device when a current of outside air is passed through it, the increase in the pressure loss, measurement of the variation in the dust collection efficiency. These helped in collecting data for deciding the timing for changing the air cleaning device.

(2) Variations in the above depending upon the locality within the Tokyo metropolitan area.

(3) Investigating the degree of atmospheric pollution in the different localities in the Tokyo metropolitan area.

3-2. Method of Testing

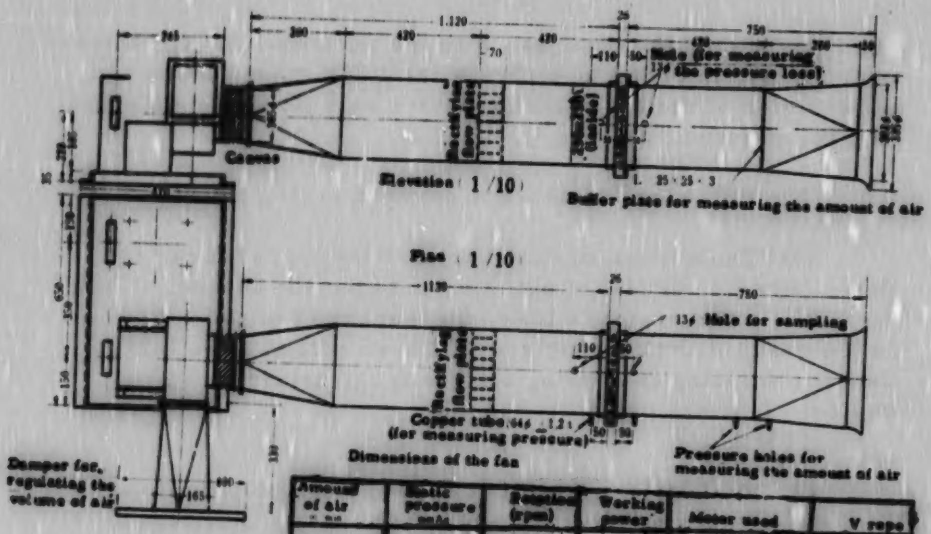
Four sets of ducts as shown in Fig. 3-1 were constructed and installed in four places mentioned below and the air cleaning device to be tested was fitted in each of them. Next the variation in the performance of the air cleaning device was determined according to the procedure described later.

(a) Roof of the second floor of the Takenaka Institute of Technology, Higashisunamachi, Koto-ku, Tokyo.

(b) Roof of the 3rd floor of the Shibaura Kōgyō University, 3 Chome, Shibaura, Minato-ku, Tokyo.

(c) Roof of the 7th floor of Koshu Eiseiin (Institute of Public Health), Shirokanedaicho, Minato-ku, Tokyo.

(d) Roof of the 2nd floor of Kenchiku Kenkyūjo (Institute of Architecture), Hyakunincho, Shinjuku-ku, Tokyo.


1,120
260
420
420
70
26
750
110
50
Hole (for measuring the pressure loss)
280
Canvas
Rectifying flow plate
Filter (inside)
L 25 × 25 × 3
Elevation 1/10
Buffer plate for measuring the amount of air
Plan 1/10
1130
26
750
13φ Hole for sampling
110
50
Rectifying flow plate
Copper tube 6φ × 1.2t
(for measuring pressure)
50
50
Pressure holes for measuring the amount of air
Damper for regulating the volume of air
Dimensions of the fan

Amount of air	Static pressure	Rotation (rpm)	Working power	Motor used	V rope
9.4	45	2747	0.36	0.75kW 4 P 100 V 50~	A-1

Fig. 3-1. Device for carrying out dust collection test with air filter.

Again, the concentration of the dust in the atmosphere was also monitored daily while carrying out the tests mentioned above.

(1) The air cleaning device used was air filter made from glass fiber, which is in most common use. The shape of the filter here was made to order so that it fitted properly inside the duct. The filter has been shown in Photo 1.

Dimensions: 290 mm x 290 mm x 22 m (thick).

Glass fiber: diameter 20 μ Density: 57 kg/m^3.

(2) Operating the testing duct and measurement

a) The air cleaning device mentioned above was fitted in the testing duct, the fan was switched on, and the speed of the air current inside the duct was set at 1.5 m/s by manipulating the damper.

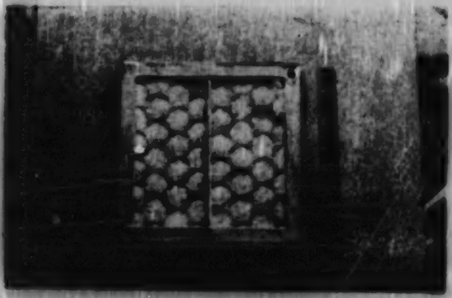


Photo. 1. Air filter used in the test.

b) The duct was operated for six days a week with the sunday as the day of rest. It worked for 8 hours between 9.00 A.M. and 5.00 P.M. from monday till friday, and from 9.00 A.M. to 12.00 noon on saturday.

c) The concentration of dust in the atmosphere was measured with the help of Automatic Continuous Roken Filter Paper Dust Gauge (Renzoku Jido Roken Roshi Jinaikei) (volume of air sampled: 3 ℓ/min). The measurement was carried out once every hour during the period the test was conducted. 30 ℓ of air was sampled (for 10 min) during each measurement, and the result was expressed in terms of optical density (Photo 3).

Photo. 3. Device for measuring the atmospheric pollution.

d) The variation in the pressure loss due to accumulation of dust was measured daily just before and after the air cleaning device for the purpose. Simultaneously the speed of the air current inside the duct was also recorded.

e) The increase in the weight of the air cleaning device was measured every wednesday after the days test was over. The air cleaning device was removed from the duct very gently and weighed in a balance having 0.1 g precision. In order to see the variation in weight due to humidity, another air-cleaning device was kept hanging near the testing duct, and the variation in its weight was also noted.

f) In the Institute of Architecture (Kenchiku Kenkyūjo), the variation in the dust collection efficiency of the air cleaning device was measured every week using test dust as the atmospheric dust.

A view of the testing duct has been shown in Photo 2.

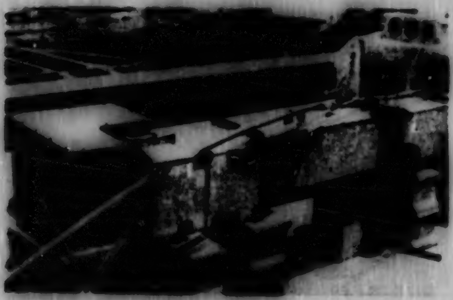


Photo. 2. Testing ducts.

3-3. Results of the Tests

(1) Variation in the concentration of the dust in the outside air

An example of the variation in the dust concentration optical density) during the period of testing has been shown in Fig. 3-2. Here the dust concentration at the same instants in the four places where the measurements were carried out has been recorded.

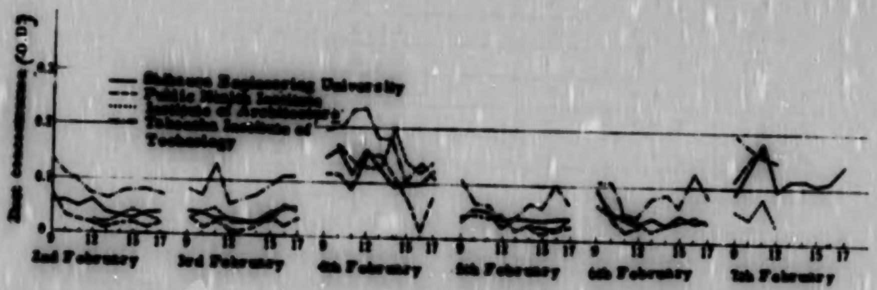


Fig. 3-2. An example of the variation in the dust concentration in the air.

(2) Relation of the amount of dust in the atmosphere with the pressure loss and the increase in weight (amount of dust captured) of the air cleaning device

In determining the amount of dust to which the air cleaning device exposed, first the amount of dust per day was calculated by multiplying the mean dust concentration for every day $(O.D.)_{mean}$ by the volume of dust passing through the duct for the day. The cumulative value of these amounts for the period of experiment gave the total amount of dust passing through the air filter.

In short, the value $(O.D.)_{mean}$ X mean air speed X filter area X hours of operation X 3600, was calculated for each day, and the value obtained for every day was added for the period of experiment. This value has been termed here as the cumulative amount of pollution (O.D. X m^3), and the calculated value of the cumulative amount of pollution has been shown in Table 3-1.

The relation between the cumulative amount of pollution and the increase in weight has been shown in Fig. 3-3, and that between the cumulative amount of pollution and the pressure

TABLE 3-1
Calculation of the cumulative amount of pollution

Shibaura Engineering University

February	O.D. [illegible]	Flow speed [illegible]		Increase in weight	Pressure loss	Pressure loss (1.3 m/s)	[illegible] amount	Cumulative amount of pollution
2	0.043	1.43	9		14.6	16.1	111	
3	0.035	1.50	9		15.5	15.5	95	206
4	0.123	1.45	9		17.0	18.2	321	527
5	0.038	1.48	9		21.1	21.8	101	628
6	0.043	1.50	9		22.1	22.1	116	744
7	0.124	1.45	4		21.8	23.3	121	865
8								
9	0.055	1.50	9		22.3	22.3	149	1014
10	0.033	1.45	9		23.3	24.9	86	1100
11								
12	0.087	1.45	9	2.5	28.5	30.5	227	1327
13	0.090	1.45	9		31.9	34.2	235	1562
14	0.073	1.45	4		35.7	38.2	72	1634
15								
16	0.053	1.40	9		37.9	43.6	134	1768
17	0.103	1.40	9		39.5	45.4	260	2028
18	0.064	1.24	9		43.8	63.9	143	2171
19	0.103	0.89	9	7.7	50.6	143.6	165	2336

Takenaka Institute of Technology

2	0.088	1.40	9	0.5	15.7	18.2	220	
3	0.088	1.40	9	1.0	17.5	20.1	220	440
4	0.171	1.32	9	4.8	20.7	26.7	402	842
5	0.064	1.20	9	5.9	20.4	31.8	137	979
6	0.080	1.25	9	6.2	22.3	32.1	178	1157
7	0.164	1.20	4	7.4	22.9	35.7	156	1313
8								
9	0.096	1.18	9	7.6	24.1	38.9	202	1515
10	0.077	1.15	9	8.6	26.7	45.3	158	1673
11								
12	0.144	1.13	9	11.6	27.2	47.8	290	1963
13	0.120	1.10	9	14.4	29.8	55.4	235	2198
14	0.121	1.10	4	14.6	27.3	50.8	105	2303
15								
16	0.109	1.05	9	15.9	32.5	66.3	204	2507
17	0.153	1.00	9	17.6	30.0	67.5	273	2780
18	0.158	0.85	9	19.7	31.6	98.3	239	3019

MAINTENANCE & SUPERVISION OF AIR CLEANING DEVICES

Public Health Institute

1	2	3	4	5	6	7	8	9
2	0.025	1.10	9				56	
3	0.020	1.10	9			11.0	45	101
4	0.104	1.09	9	0.6		12.3	231	332
5	0.016	0.56	9			12.2	18	350
6	0.032	0.72	9			14.0	44	394
7	0.141	0.62	4	1.8		14.2	78	472
8								
9	0.035	1.11	9			15.3	79	551
10	0.029	1.11	9			15.6	65	616
11	0.035		9	1.3			77	693
12	0.075	1.10	9			16.0	167	860
13	0.066	1.10	9	2.8		19.9	147	1007
14	0.058	0.93	4			20.4	49	1056
15								
16	0.048	1.10	9			21.0	107	1163
17	0.106	0.68	9			22.3	147	1310
18	0.123		9				273	1583
19	0.117	1.10	9	4.8		23.1	260	1843
20	0.071	1.09	9	7.3		23.2	157	2000

Institute of Architecture

2	0.0275	1.62	6		16		60	
3	0.037	1.62	8				108	168
4	0.144	1.62	8				420	588
5	0.028	1.62	8	2.2	16.8		82	670
6	0.038	1.62	8				111	780
7	0.051	1.62	3				56	835
8								
9	0.035	1.62	8				102	937
10	0.068	1.62	8	4.0	17.5		198	1135
11								
12	0.056	1.62	8				163	1299
13	0.072	1.62	8				210	1509
14	0.030	1.62	3				33	1541
15								
16	0.082	1.62	8	4.9	20.8		239	1780
17	0.082	1.62	8				239	2019
18	0.150	1.62	8	6.6	22.3		437	2467
19	0.136	1.62	8				397	2863
20	0.093	1.62	8				271	3135

loss at 1.5 m/s flow speed has been shown in Fig. 3-4. In both the relationships, a comparison of the values obtained at the four sites has been shown for the period 2nd to 20th February.

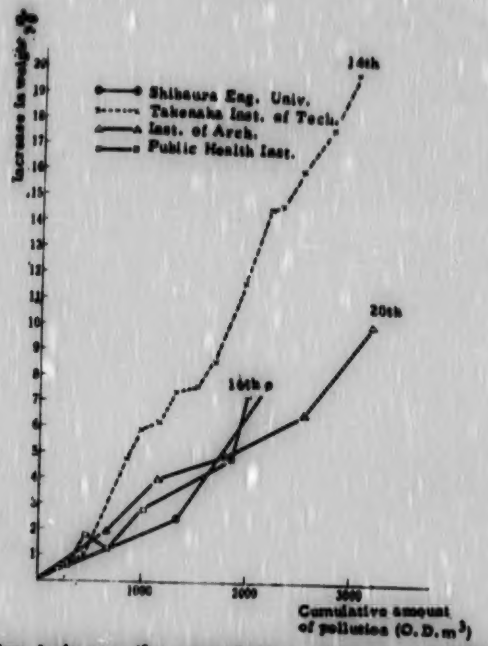


Fig. 3-3. Relation between the cumulative amount of pollution and the increase in weight.

3-4. Study of the Results

The following conclusions were drawn from the results given above.

(1) Relation between the cumulative amount of pollution and increase in weight

From Fig 3-3 it will be seen that the cumulative amount of pollution and the increase in weight are more or less directly proportional to each other. Excepting for the Takenaka Institute of Technology, where the rate of weight increase showed abnormally high value, the values in the other three places

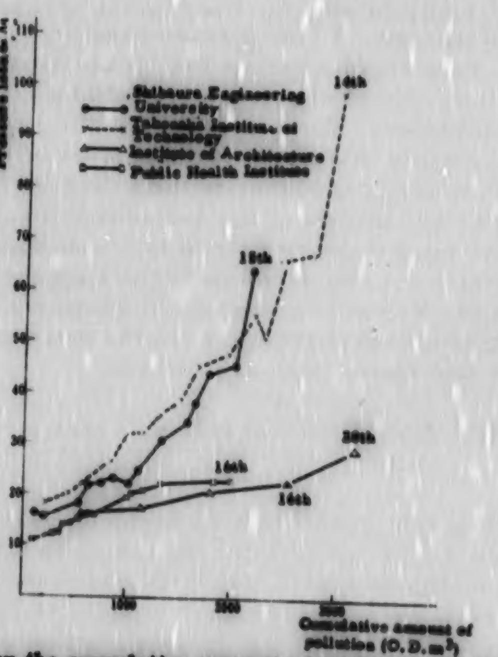


Fig. 3-4. Relation between the cumulative amount of pollution and pressure loss.

roughly agreed mutually. The reason for the abnormally high value at the Takenaka Institute of Technology may be due to the presence of a large number of industries in the neighborhood of the Institute. Because of these industries the air probably contained dust particles with large diameter in higher proportion which resulted in larger increase in weight compared to the cumulative amount of pollution calculated with the help of optical density.

(2) Relation between the cumulative amount of pollution and pressure loss

As shown in Fig. 3-4, the pressure loss also increases with the increase in the cumulative amount of pollution. However, the relation shows two viz. the relationship for the Shibaura Engineering University and for the Takenaka Institute of Technology showing one pattern, and that for the Public

Health Institute and the Institute of Architecture showing another pattern. In the former case the increase in pressure loss is very rapid whereas that in the second case it is rather very slow. No precise reason could be found for this difference in the behavior. Tests carried out till now have revealed that when the air contains the same amount of dust, the smaller the dust diameter, the higher is the pressure loss. However, not much can be said about the granularity of the atmospheric dust here, as optical density alone has been mentioned in the X-axis. At any rate the above two patterns suggest that the nature of dust in the Yamate area where the latter two institutes are located is different from that in the down town area where the former two institutions are located.

(3) Comparison of the concentration of dust in the four areas

The dust concentration in the outside air was highest in the Koto-ku area where the dust concentration during the daytime over the period 2nd to 23rd February showed the mean O.D. value of 0.130. As against this, the dust concentration in the other three places was lower, the mean O.D. value being in the range 0.0623~0.0773.

(4) Relation between the cumulative amount of pollution and the dust collection efficiency

The dust collection efficiency was determined only in the case of Institute of Architecture. The dust collection efficiency was studied by the method of decoloration. The efficiency was found to be 22% in the case of the unused brand new filter. However, the collection efficiency increased with the increase in the cumulative degree of pollution. The efficiency reached the 40% figure when the cumulative amount of pollution reached around 3000.

(5) On the timing for changing the filter

If the timing for changing the filter is set at the stage when its pressure loss becomes double, then from Fig. 3-4 it will be seen that the filter used in the current study should be changed when the cumulative amount of pollution reaches around 1000-1500 in the cases of Takenaka Institute of Technology and Shibaura Engineering University, and around 3000 in the cases of Public Health Institute and Institute of Architecture.

Again, when converted into number of days, the filter should be changed every 5~7 days in the former case and every 20 days or so in the latter case, assuming that the use is confined to the daytime alone. The life will be reduced to half in case the filter is used continuously during the day and night.

4. Continuous Monitoring of the Air Cleaning Devices over a Prolonged Period

4-1. Object

It is necessary to pay proper attention to maintenance and supervision of the air cleaning device besides making provision for proper air cleaning at the time of designing the building, in order to maintain the air inside the building at the proper level of cleanliness. Although a large number of experiments have been carried out on the operational characteristics of the air cleaning devices in the laboratory and voluminous data have been obtained, yet very few experiments have been conducted with the devices in the actual working state. Here the characteristics of an air cleaning device in actual operation in a building were monitored continuously in order to obtain data for formulating a basis for maintenance and supervision of the air cleaning device. The findings will be discussed here.

4-2. On the Building Where the Investigation was Carried Out

(1) Position of the building and the purpose for which it is used

The building where the study was carried out is located in the commercial area as shown in Fig. 4-1. There are a large number of wholesalers and small-scale chemical plants in the area and the automobile traffic density is also very high. The building concerned is surrounded by two-storey wooden structures and small-sized buildings. The ground floor of the building accommodates shops and show rooms, and the first floor accommodates the rented offices.

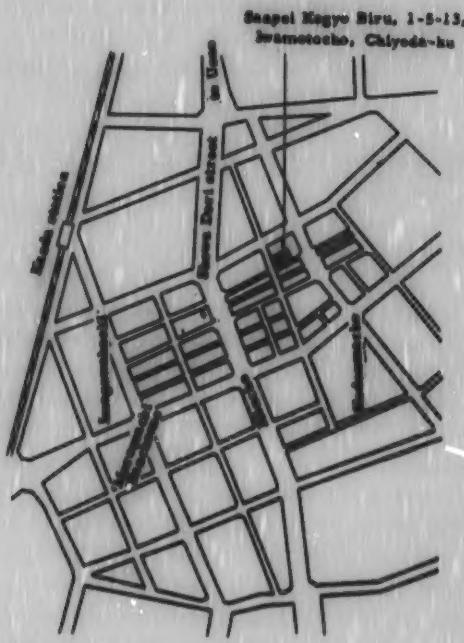

Sanpei Kogyo Biru, 1-5-13,
Iwamotocho, Chiyoda-ku
Kanda station
Showa Dori street
to Ueno

Fig. 4-1. The location of the building

(2) Dimensions of the building

The dimensions of the building are as follows.

Construction : Reinforced ferroconcrete, 6 storey
Area : Building site - 833.6 m^3; Standard floor - 754.2 m^2; Ceiling height - 2.45 m
Finishing : Ceiling - sound absorbent perforated board; Walls - Zoracoat; Floor - Plastile

Air conditioning : The whole building is covered by a single system with ducts
Air cleaning device : Automatic winding roll-type glass filter.

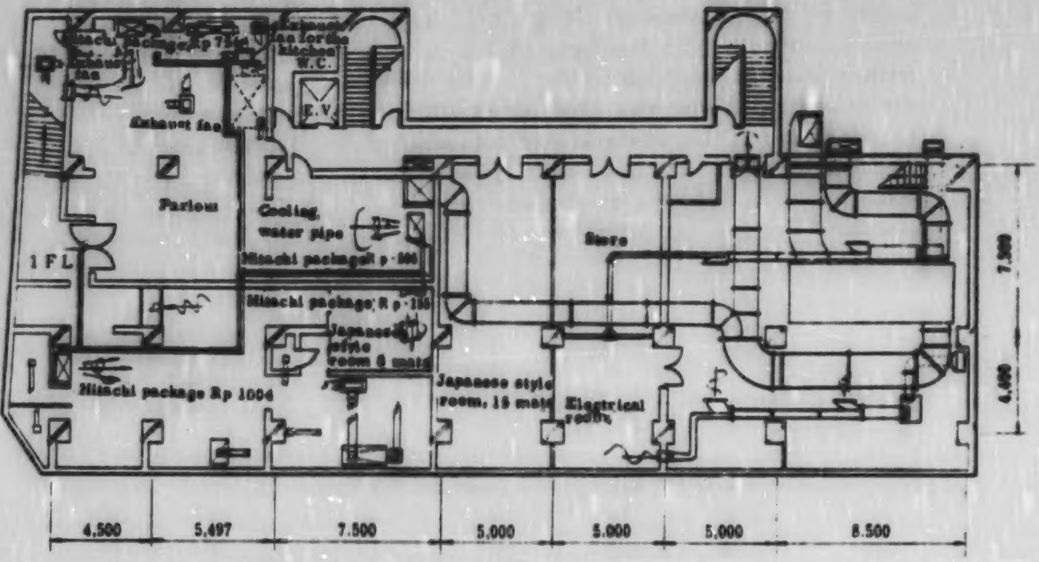

Exhaust fan for the kitchen
W.C.
E.V.
Exhaust fan
Parlour
Cooling water pipe
1 FL
Store
Hitachi package Rp 1004
Japanese style room 6 mats
Japanese style room, 15 mats
Electrical room
4,500
5,497
7.500
5,000
5.000
5,000
8.500
7,300
4,000

Fig. 4-2. Sanpei Kogyo Honsha Biru; Sketch of BFL air conditioning and exhaust system.

(3) On the air cleaning device

Automatic winding type air cleaning device has been used here, and at the time of normal working, about 120 mm of the filter is wound up at the interval of every 16 hours. The filtering material consists of glass fiber mat where adhering agent has been used. It is abandoned after use.

In the present study, the winding mechanism was turned off after exposing a fresh filter, and the cumulative state of pollution was monitored continuously. The air speed in the space in front of the filterr was 1.7 m/s on the average.

4-3. Method

(1) Method of measuring the concentration

Sampling tubes as shown in Fig. 4-4 were provided before and after the air cleaning device in the air conditioner in the positions shown in Fig. 4-3, and 3ℓ of air was drawn out per minute with the help of a 5 m long vinyl chloride tube with 9 mm internal diameter. The dust concentration in the air thus drawn out was measured with the help of Roken Filter Paper Dust Meter. Air was drawn out for 10 min in every test, and the test was repeated for 10 to 20 times with 2 min rest in between two consecutive tests. The results obtained for the air sampled out before and after the filter were compared.

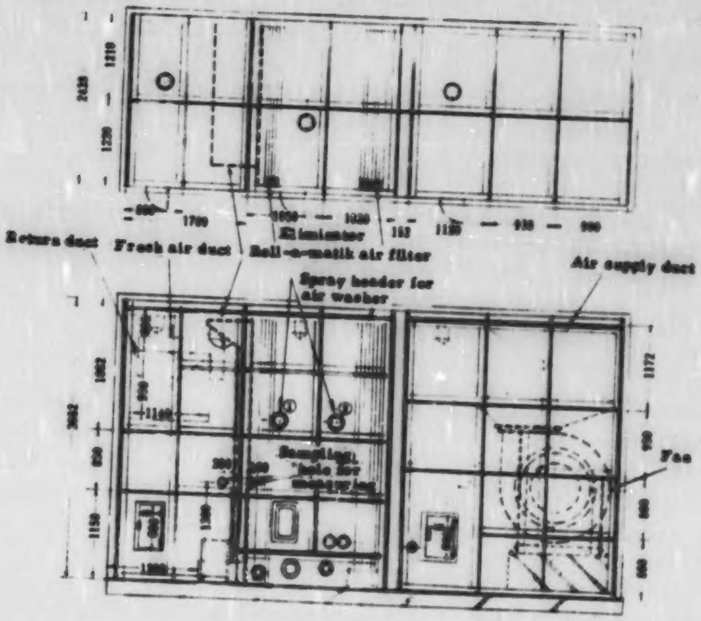

1210
1220
1700
1030
152
1130
910
990
Eliminator
Return duct
Fresh air duct
Roll-o-matik air filter
Air supply duct
Spray header for air washer
1100
Sampling hole for measuring
1172
Fan
1150

Fig. 4-3. Air conditioner.

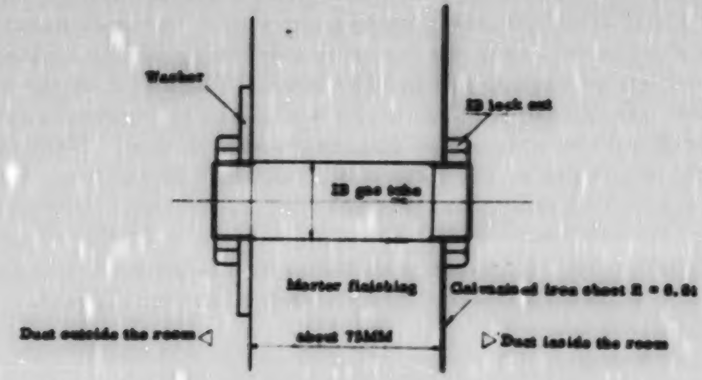


Fig. 4-4. Cross section of the sampling hole.

(2) Method of measuring the pressure loss

The pressures at the two pressure measurement spots located on either side of the air cleaning device were measured with the help of slanting manometers filled with distilled water. As the air current was turbulent inside the chamber, the level inside the manometer was moving up and down. So the reading at the intermediate position was recorded.

(3) Method of determining the volume of air

As constructional difficulties are involved in measuring the volume of air either inside the duct or at the supply or exhaust openings, traverse measurement of the air speed at the return duct opening inside the air conditioner chamber just before the air cleaning device was carried out, and the mean air speed was calculated from the values obtained. Next the volume of air was calculated by multiplying the mean air speed with the area of the return duct opening. The air speed was measured with the help of anemometer of Nihon Kagaku Kōgyō Co.

(4) Method of determining the collection efficiency

The collection efficiency of the air cleaning device was determined from the values of concentration (Optical density

= - log I/I_0, where I_0, I are the optical transmission rate before and after the air cleaning device) measured before and after the air cleaning device with the help of Roken filter paper dust gauge as mentioned in (1) above. The ratio of the concentrations before and after the air cleaning device was determined from the above two concentration values. Next the arithmetic mean of the ratios of concentrations thus obtained for each set of concentration measurements was determined (here the maximum and the minimum values of the ratios were excluded), and this mean was taken as the rate of transmission (= 1-collection efficiency) for the set of measurements.

4-4. Results

The results obtained after conducting the measurements have been shown in Table 4-1, Fig. 4-5 and Fig. 4-6.

TABLE 4-1

Results of the experiments

Date	Pressure loss	Collection efficiency	Volume of air	Fan current	
	mmAq	%	m^3/s	A	
21	4.5	14.9	14.5	8.0	
28	6.5	26.3	12.9	8.1	
March 7	8.0	17.1	12.0	8.1	
14	9.0	17.1	11.4	8.1	
20	11.0	22.2	12.8	7.9	
28	11.5	20.2	10.2	8.1	
April 4	14.5	13.9	12.4	8.3	
11	19.5	15.0	12.0	8.1	
15	16.0	19.5	12.9	8.2	After winding
	8.5	20.0	13.1		
18	7.5	15.0	11.9	8.1	

In this particular experiment the filter was kept fixed by disconnecting the automatic winding device. After keeping the filter in fixed position for 60 days, the winding device was switched on from the 1st day. As the winding went on normally up to the forenoon of the 63rd day (the automatic winding was carried out via a timer device), about 12 cm of fresh filter was exposed. Furthermore, down the pressure loss to the

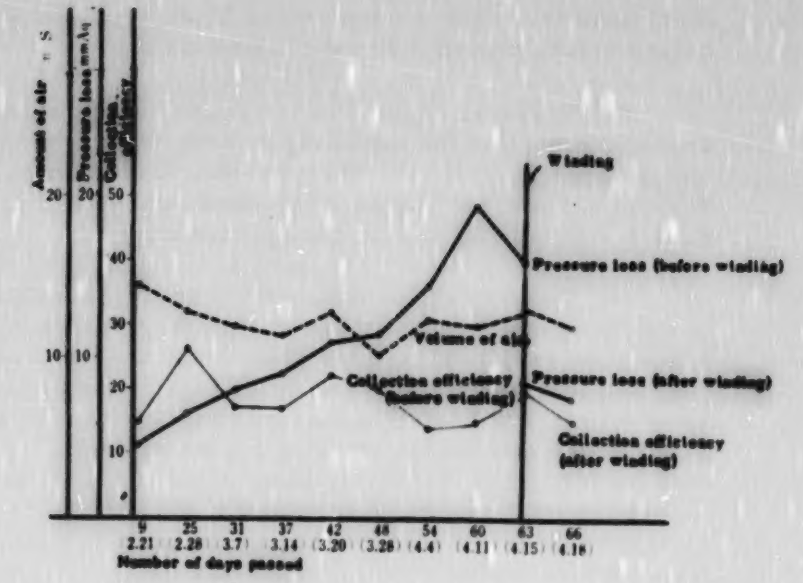


Fig. 4-6. *Results of measurements.*

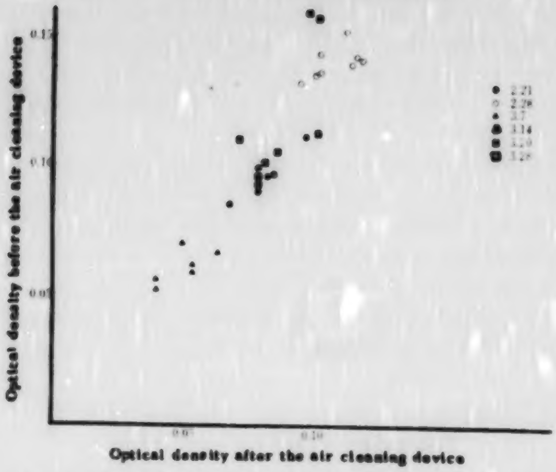


Fig. 4-6. ***Corelation of the optical density values before and after the air cleaning device.***

level usually observed during normal working of the filter (8-11 mmAq). The normal working was continued for three more days (here the winding of the filter continued automatically) before ending the experiment on the 60th day.

(1) Pressure loss: The pressure loss increased from around 8 mmAq in the beginning to around 19.5 mmAq over a period of about 60 days. The pressure loss, however, came down to 8.5 mm rapidly once the winding started, which came down further during the following three days.

(2) Dust collection efficiency: The collection efficiency of the fresh new filter was low during the first week of exposure, which rose rapidly during the second and the third weeks reaching the peak value of 26%. The following 20 days were again a period of low collection efficiency with minor ups and downs in the efficiency, showing a gradual decline over the whole period. The efficiency came down to 13.5% as the filter was wound up. Just after winding up, the efficiency value returned to the pre-winding value, but went down again to 15% during the following two days (66th day).

(3) Volume of air sent: The volume of air increased from 11.9 m^3/s at the time of exposure of the fresh filter to 14.5 m^3/s on the 19th day following which the volume of air fluctuated till it approached a value around 12 m^3/s. The power supplied to the fan was however constant without any fluctuation.

In the present study, the total circulation system was adopted in the air conditioning. However, when the air circulation of the building as a whole was taken into consideration, it was found that a large volume of outside air leaked in through the entrance located on the ground floor. So it was felt that the whole system was, in practice, in a state where the normal amount of outside air was drawn in.

4-5. Study

As the present study was confined to a single type of filter and since only one series of monitoring was carried out, it is very difficult to carry on a generalized discussion. So the discussion will be carried out within the scope of the conditions set up for the present study.

(1) On the collection efficiency: After a fresh air cleaning device of the type is exposed, the collection efficiency goes on increasing with the increase in the accumulation of dust. It has been found that such increase in efficiency amounts to about 25%

Furthermore, the subsequent trend of decline with repeated ups and downs is a matter of great interest. The initial increase is due to collection of dust, but the cause of fluctuation after the peak is not very clear. The captured dust here probably formed agglomerates under the action of the moisture in the air, thus bringing about a change in the structure of the dust layer. Again, the dust agglomerates thus formed may have fallen off due to the vibration of the filter induced by the air. At any rate the fluctuation mentioned above is an important factor in the determination of the dust collection capacity of the filter. As the winding of the filter was carried out automatically, there was a probability of reentrainment (i. e. flying off) of the captured dust. To study this prospect, measurement of the collection efficiency was carried out during the winding of the filter. Here the collection efficiency showed a slight decline suggesting only a minor degree of reentrainment of the captured dust. As the filter is normally in a state of vibration, the extent of vibration caused during the winding of the filter probably fails to exert much influence. And again, even if there is reentrainment of the dust, yet the mode of sampling adopted probably fails to reflect this on the results. The conclusion arrived at by the team was that a reappraisal of the method of measurement is needed on this score.

The decline in the collection efficiency after switching on of the normal automatic winding operation following the winding up of the filter also could not be explained properly.

(2) Pressure loss: The pressure loss showed a trend of steady increase after the second week, but the increase became rapid after the seventh week. This finding suggests that the filter continued to collect dust during the whole course of the present experiment and also that there occurred no decline in the collection efficiency here due to reentrainment of the dust. Here the experiment was stopped after 60 days out of

consideration of various factors, and hence the behavior of the pressure loss after sixty days remained unknown.

4-6. Conclusion

The initial collection efficiency of the filter used here (glass-fiber mat, oil applied) was low, but it increased as the amount of dust collected by the filter increased. However, the collection efficiency showed a downward trend while undergoing fluctuation once the peak value was crossed.

The pressure loss rose to about 20 mmAq from the initial 3 mm H_2O (1.7 m/s).

These results suggest that the conventional procedure of using the initial collection efficiency or the initial pressure loss as a basis for determining the life of the filter is not very sound. Again, the difficulty involved in using the peak value is that it is not possible to determine the critical curve from the few waves in the collection efficiency curve obtained from the laboratory experiments.

5. Concluding Remarks

The experiments discussed in the Section 3 and 4 in the present paper are the newly conceived ones without any precedence. So there remained many shortcomings both in the procedure as well as in compilation of the results. Again, the results also cannot be said to be that encouraging. The points which remained unsolved in the present study should be solved in future by carrying out careful experiments.

In the end, the team wants to express thanks to the various supervisory staff members of the various buildings where the study was carried out, as well as to Sugiura, Murakami, Nomura and others for their assistance in compiling the results obtained. Again, the team also expresses gratitude to the authorities of the Sanpei Kōgyō Biru and Shinwa Bōeki K.K. where the continuous monitoring experiment was carried out, as well as to Irie, Tsuchiya, Takahashi, Tsukamoto and Kobayashi who assisted in conducting the experiment.

MAINTENANCE AND SUPERVISION OF THE PERFORMANCE OF ELECTRICAL AIR CLEANING DEVICES

E.KAMEKO

1. Introduction

Construction of multistorey buildings and hotels has been going on at an accelerated pace all over Japan during the past ten and odd years. According to the figures published by the Ministry of Municipal Government, the construction of non-residential concrete and ferroconcrete buildings has gone up from 49,489 in 1958 to 192,851 in 1968, a four-fold increase over a period of ten years.

The recent advances in the architectural technology and the demand for higher utilization rate of land in the urban area have set a trend for larger and taller buildings; and it can rightly be said that Japan is slowly emerging into the super multistorey era from the multistorey era. Headed by the Kasumigaseki Mitsui Building (36 storey, 147 m), World Trade Center Building (40 storey, 152 m) and Keio Plaza Hotel (47 storey, 168 m), there are more than 50 buildings taller than 160 m which have either been constructed or are at different stages of construction.

However, this era of super multistorey buildings is coming at the time of aggravating atmospheric pollution requiring proper conditioning of air for the creation of a pleasant environment inside the room. Although the concept of air conditioning originally developed with the object of regulating the temperature and humidity inside the room, yet the atmospheric pollution has put in the new demand for removal of the pollutants, especially the dust, from the air drawn from outside and fed to the air conditioner, as well as for removal of the dust created within the rooms from the circulating air.

The most noteworthy development in this field is the promulgation on 14th April this year of the "Law concerning Maintenance of Hygienic Environment inside the Buildings", which had been under active consideration in the National Diet eversince May 1968.

The draft of this act has been given at the end of the paper in order to give an idea of the specifications laid down for temperature, humidity, dust, microorganisms and injurious gases etc. This act covers, as the first step, the buildings with more than 8000 m^2 gross floor area or buildings accommodating more than one thousand persons; and diverse types of buildings like office buildings, departmental stores, commercial centers, shopping centers, schools, hospitals, government offices, libraries, art galleries, museums, gymnasiums, dormitories, inns, stations, airport terminal buildings, and passenger handling facilities of the ports etc. come under the scope. It is highly gratifying indeed that law has at last taken cognizance of the grave importance of maintaining proper environment inside the buildings.

The objectives of the air cleaning can be broadly divided into two categories. One is for maintenance of healthv and hygienic environment inside the building which has come under the purview of the above mentioned act. The other is for industrial purpose covering various industries like the semiconductor industry, optical instruments industry, precision instruments industry, laboratories, paint industry, fiber industry and chemical industry necessitated by the stringent requirements for maintenance of the stipulated quality. Diverse types of air cleaning devices have been developed to suit the diverse types of uses, and today the filtering technology has advanced to the extent where it is possible to obtain air completely free from dust above the 0.3 μ size.

In the conventional type air cleaning devices, mechanical filter or electric air cleaning mechanism is fitted individually or jointly to ensure the degree of cleanliness determined beforehand. The relative superiority of the mechanical filter and the electrical air cleaning mechanism is evaluated on the basis of their collection efficiency, ventilation loss, economy and difficulties involved in maintenance etc. However, it must not be lost sight of the fact that the dust floating about in the atmosphere mostly consists of particles of size below 5 μ (about 80 ~ 85%), and the mechanical filters are thoroughly inadequate for such fine dust particles, whose removal is of primary consideration from the point of health.

Till now there had been an apathy towards the electrical air cleaning device because of the relatively high installation cost involved and the requirement of troublesome accessories like water supply and drainage device etc.; but of late the picture has started changing slowly and the electrical air cleaning devices are becoming more and more popular as the customers have started realising that the collection efficiency is very high even for the fine dust and that the absolute value and the fluctuation in the ventilation loss are low, both these factors being unmatched by any other type of air cleaning device. In short, the electrical air cleaning device proves very economic when the collection efficiency and the running cost are taken into consideration; but the factors that influence the past installation efficiency of the device are proper maintenance and inspection, and even the costly device installed with so much expectation will fail to produce the desired effect once these are neglected.

The ponts for which proper care should be taken for maintaining the post installation efficiency of the electrical air cleaning device will be discussed below.

Again, as the space is very limited, the discussion on the maintenance and supervision of the automatic filter winding type electrical air cleaning device will be postponed to a future occasion.

2. Points for which Care Should be Taken While Selecting the Device

The electrical air cleaning devices do not create any problem insofar as the efficiency is concerned when they are intended for cleaning the normal outside air and the circulating indoor air in the ordinary buildings. However, if the devices

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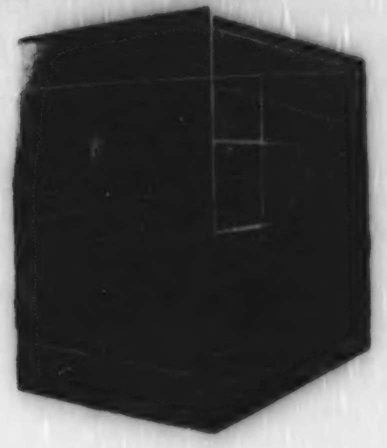

Photo 1. Frame assembly type electrical air cleaning device.

Photo 2. Cabinet type electrical air cleaning device.

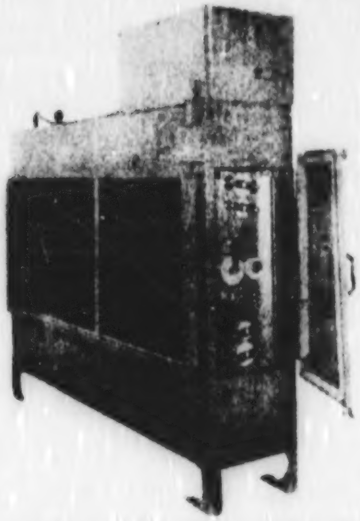

Photo 3. Appearance after fitting of the dust collection unit.

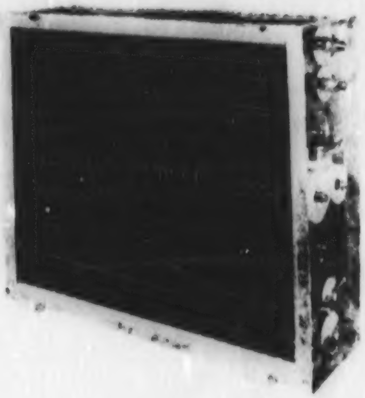

Photo 4. Dust collection unit.

are meant for handling special type environments as mentioned below, then proper care should be taken for providing adequate facilities for dealing with the situation.

(1) Environment with abnormally high concentration of dust

When the environment contains an abnormally high concentration of dust, there occurs a deficiency in the amount of charge required for the dust resulting from the decrease in the ion current in the ionization section as well as a decline in the ionisation action due to the fattening of the discharge wire with the accumulation of dust. These two actions naturally bring about a deterioration in the collection efficiency of the electrical dust collector. Again, as the accumulation of dust on the dust collection electrode plate far exceeds the normal amount, short circuit occurs readily, which calls for an increase in the frequency of cleaning.

It is necessary to provide mechanical filters like roll mat filter or unit filter in front of the electrical air cleaning device in order to bring down the level of dust concentration up to the level of the rated treatment concentration of the electrical air cleaning device so that it can work efficiently in such an environment.

(2) Environment with high concentration of fibrous dust

Normally, the electrical resistance of the fibrous dust is high in dry state. Hence, short circuit occurs relatively rarely even if the fibrous dust spreads in between the dust collecting electrode plates. However, the position changes during the rainy season or on the rainy days. As the outside air is highly humid, the fibers absorb moisture from the air introduced from the atmosphere and become conductive thereby causing short circuit and bringing down the efficiency.

Hence, it is necessary to use eliminator which can be maintained very easily in front of the electrical air cleaning device when installing it in a place like spinning mill where a large amount of fibrous dust is produced.

(3) Environment with high concentration of conductive dust

The captured conductive substances like metallic powder or water drops cause short circuit in between the dust collecting electrode plates while falling due to the action of gravity. The frequency of short circuit increases with the increase in the amount of the conductive substance and the frequency of falling, which in turn brings down the collection efficiency considerably.

Again, when the conductive substance increases in proportion in the environment, it brings about a surface short circuit by adhering on the high voltage glass and the fixed glass provided for protecting the dust collecting electrode plates, as a result of which the device loses its capacity to collect dust.

Furthermore, when the outside air and the indoor circulation air do not get mixed well in the mixture chamber and come in contact with the dust collecting electrode plates in an unbalanced manner at the time of air conditioning (heating or cooling), there occurs dewing of the electrode plates due to the rapid variation in temperature, which brings about short circuit of the electrode plates. Therefore, proper care should be taken to ensure thorough mixing of the outside air and the indoor circulation air in the mixture chamber.

(4) Environment with high concentration of corrosive gas

The dust collecting electrode plates of the electrical air cleaning device are made mainly from aluminum of high degree of purity. So, the device is unsuitable for treating environmental air containing a high proportion of gas capable of corroding the constituents of the electrode plates.

(5) Environment containing explosive gas

In general, the ionization section and the dust collection section are impressed with DC 10~11 KV and DC 5~5.5 KV respectively, and hence short circuit accompanied by discharge occurs when some large foreign matter finds its way in between the dust collecting electrode plates or when some long fiber spreads in between the discharge wire and the earthing plate.

Thus, if the air to be treated contains combustible or explosive gases, then their concentration should be lowered to below the critical combustion or explosion limit. Thus, the electrical air cleaning device can be used only in the cases where the safety factor is confirmed to be below the critical accident levels.

3. Points on Which Care Should be Taken While Using the Device

The points for which care should be taken while using the electrical air cleaning device not only under the special type environmental conditions discussed above, but also under the normal environmental conditions in ordinary buildings, will be discussed next.

(1) The rated volume of air to be treated should not be exceeded

When the electrical dust collection device has a guaranteed dust collection efficiency of 90% (degree of pollution method) at the rated treatment volume, an increase of 20% in the volume of air treated over the rated value brings down the collection efficiency to 85%. Thus, the device will fail to maintain the guaranteed dust collection efficiency if it is to treat air in excess of the rated capacity. Thus, controversies arise on occasions as the device fails to show the designed dust collection efficiency. So proper care should be taken to keep the volume of air to be treated within the rated limit.

(2) The speed distribution of the air current passing through the dust collection unit should be uniform

The speed of the air at the various sections should be kept within +10% of the mean air speed while passing through the electrode plates of the dust collection unit not only when operating the device at the rated treatment capacity, but also when operating at below the rated capacity.

This uniformity of the air speed all over the filtering device is important not only in the case of electrical air cleaning device, but also in the case of the ordinary mechanical air filters. Sometimes the duct arrangement is irrational on account of limitations imposed by space, which in extreme cases creates highly unbalanced distribution in the air speed (here the air speed on the right hand side and at the bottom falls to about half of the rated air speed and that on the left hand side and on the top rises to about 1.5 to 2 times of the rated air speed). Under such a situation the device not only fails to maintain the guaranteed dust collection efficiency but even shows a decline in the partial collection efficiency in the section exposed to wind with high speed. Again, in this very section higher accumulation of dust occurs on the dust collecting electrode plates than that in the case of the rated air speed because a higher amount of air has to be treated per unit time, and such a situation necessitates an increase in the frequency of cleaning of the dust collecting electrode plates.

Again, care should also be taken against the turbulent current. In case turbulent current is present in the air stream passing through the dust collecting unit, the captured dust gets reentrained due to agitation. Under such a situation the device fails to maintain its guaranteed dust collection efficiency. Again, if the turbulation in the air stream is high, then the dust collecting electrode plates start vibrating leading to partial cracking of the fixed section of the electrode plates. Once such cracking appears, the device becomes unsuitable for collection of dust.

In such cases it is necessary to rectify the current by providing air guide on the air inlet side.

(3) Abrupt regulation of the volume of air should be avoided during the use

An abrupt change in the speed of the air current passing through the dust collecting unit should be avoided because such an action brings about a decline in the dust collection efficiency by causing reentrainment of the dust already collected on the dust collecting electrode plates and sudden agitation of the dust accumulated inside the duct on the inlet side and the consequent instantaneous transmission of a large amount of dust into the dust collecting unit.

(4) Excess amount of dust should not be allowed to accumulate on the dust collecting unit

When an excess amount of dust is allowed to accumulate on the dust collecting unit, there occurs the phenomenon of short circuit in between the dust collecting electrode plates; and if the short circuit increases in frequency a deterioration in the dust collection efficiency follows.

Such a development is signalled by switching on of the short circuit indication lamp provided on the operation console or by switching off of the operation indicating lamp. Unless some remedial step is taken immediately, the short circuit becomes a permanent feature leading to total stoppage of dust collection. When such a situation arises it becomes necessary to overhaul the entire dust collection unit as the built in washing mechanism proves incapable of washing away the accumulated dust during cleaning.

Hence, it is very important that the cleaning of the dust collection unit should be carried out strictly at the intervals specified in the maintenance instructions without fail.

(5) Comparatively large sized foreign objects like water drops, insects or paper pieces should not get stuck up in the dust collection section

It is possible to judge to a certain extent whether large foreign matters like water drops, insects or paper pieces may find their way into the electrical air cleaning device affecting the collection efficiency right at the installation planning stage from the location of the inlet of the outside air. Again, after actual installation unexpected foreign matters often find their way into the device during the four seasons.

For example, during the period from spring to autumn, the insects are quite often sucked in along with the outside air. During the winter, snow flakes and during the rainy days the rain drops are also sucked in. Again, smokes from the chimney stacks are also sucked in when the inlet for the outside air is located close to the stacks.

The suction of a large amount of rain drops causes short-circuit in between the dust collecting electrode plates, lowering of the insulation of the high voltage glass and surface short circuit. Again, presence of large foreign matter in between the dust collecting electrode plates causes permanent short circuit. So care should be taken to ensure their elimination.

The electrical air cleaning devices come in two types, one provided with prefilter which serves the dual purpose of eliminating the large foreign matters and rectifying the air current, and the other not provided with any such mechanism. Care should be taken to provide a prefilter of non-fibrous material or of wire netting of 20~30 mesh on the air inlet side to arrest the large foreign matters where no such arresting mechanism has been provided. Again, eliminator should be provided to check the penetration of the rain drops.

4. Maintenance

The maintenance of the electrical dust collecting device can be broadly summed up into the following two steps for ensuring its efficiency.

a) The dust captured by the dust collection unit should be disposed off regularly.

b) Inspection of each and every section should never be neglected.

Here, mechanical and electrical inspection of each and every part should be carried out once a month besides carrying out the periodical automatic cleaning. Again, the following points should be enforced strictly once or twice a year periodically.

MAINTENANCE & SUPERVISION OF AIR CLEANING DEVICES

(1) The dust adhering to the high voltage glass, to the discharge wire,to the dust collecting electrode plates and to the corners of the frame etc. should be cleaned and removed.

(2) The dust accumulated inside the duct and in the water drainage system should be removed.

(3) The prefilter and the after-filter provided on the air inlet side and on the air outlet side should be cleaned.

(4) Inspection of the nozzle and the Y-type strainer of the automatic cleaning mechanism should be carried out and these should be cleaned by dismantling.

(5) Earthing, terminals, connections etc. should be checked.

It is needless to say here that the strict enforcement of the above points has a direct bearing not only on the performance, but also on the life of the electrical air cleaning device. The guaranteed performance of the electrical air cleaning device is possible only when the above points are enforced properly.

Thus, the customer should either appoint properly trained staff for maintaining and supervising the electrical air cleaning device, or if such an arrnagement is not feasible, then the customer should enter into an agreement with the manufacturer and entrust the maintenance to the latter. In short, maintenance should never be neglected under any pretext.

The short circuit in the dust collection section can be listed as the main abnormality occurring in the electrical air cleaning device during operation, and this short circuit is indicated by the operation indication lamp provided on the operation console or on the remote monitoring console. Here, the current limiting reactor provided in the high voltage generation section automatically checks the abnormal current of the power source at the time of short circuit in the dust collection section or when the corona discharge of the discharge wire changes into arc discharge, and the voltage on the primary side of the high voltage transformer becomes zero. When this happens the short circuit is indicated by switching off of the operation indication lamp. Thus, when the operation indicating lamp goes off, it usually means that there has occurred some sort of abnormality in the dust collection unit like unusual accumulation of dust or penetration of large foreign object or the rain drops, or snapping of the discharge wire etc. However, on rare occasions the cause can be traced to the abnormality in the power source including weakening of the insulation of the high voltage wiring.

A constant watch should be kept on the operation indication lamp when the electrical air cleaning device is under operation, and if the lamp gets switched off continuously for long, immediately a thorough check-up should be carried out to pin point the fault and the necessary remedial steps should be taken without any delay.

Again, there are also occasions when the operation indication lamp goes off instantaneously. The cause for this lies in instantaneous large volume of dust being carried by the incoming outside air or the introduction of foreign objects. Such a behavior of the lamp can be overlooked so long as the frequency of the switching off remains low.

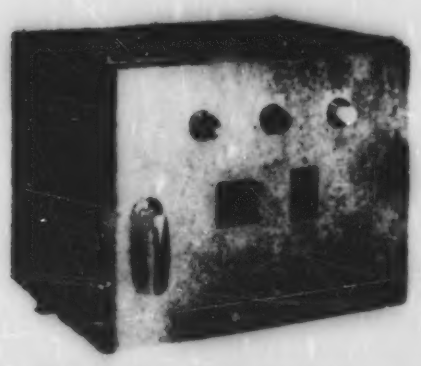

Photo 5. Outside view of the operation console.

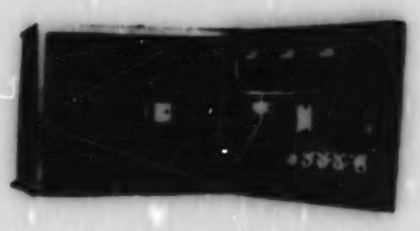

Photo 6. Inside view of the operation console.

4-1. Plan for Cleaning

The frequency of cleaning of the electrical air cleaning device with the help of the built in automatic cleaning mechanism cannot be determined uniformly beforehand as the various environmental and seasonal factors are involved. Since the dust collection efficiency decreases with the accumulation of dust on the dust collecting electrode plates, the automatic cleaning can be carried out on a convenient date determined beforehand on the basis of the state of accumulation of dust observed visually. In short, automatic cleaning should be carried out at least once a week when the electrical air cleaning device is installed in a normal environment so that it can continue to work maintaining the guaranteed dust collection efficiency.

Even though the automatic cleaning may be carried out according to the schedule quite appropriate for the location, yet when the device is used over a very long period, insoluble dust left behind at the time of washing gets adhered to the various parts. Thus, it is desirable that the dust collection unit should be taken out at least once in a year and the dust collecting electrode plates, the high voltage glass and the frame etc. should be overhauled.

Again, the dust accumulates in the prefilter or in the after-filter or in the exhaust water receiver etc. when the electrical air cleaning device is used over a prolonged period; and the dust thus accumulated peels off and starts flying in the form of large agglomerates. So it is necessary to clean these parts also at least twice a year.

Thus, the frequency of cleaning cannot be determined beforehand as this depends upon the conditions under which the device works. The cleaning interval should be determined after taking the factors like the amount of dust accumulating on the dust collecting electrode plates, the frequency of short circuit and the environmental conditions prevailing at the place of installation etc. After determining the interval, a cleaning schedule should be drawn up which should be enforced very strictly. For example, the cleaning should be fixed at the time when the layer of dust accumulated reaches a thickness of about 1.5 mm. After fixing the cleaning interval, the convenience of the maintenance staff, the holiday, the day of rest of the machine etc. should also be kept in view while drawing the cleaning schedule. An example has been shown in Table 1 below.

The built in automatic cleaning mechanism comes in two types, one type with fixed cleaning tube and electromagnetic valve switch-over mechanism and the other type with travelling cleaning tube mechanism. The fixed cleaning tube and electromagnetic valve switch-over mechanism has the following construction.

The automatic cleaning device consisting of a main tube, a Y-shaped strainer, electromagnetic valve, branch tube and spray nozzles is provided in between the after-filter on the air inlet side and the dust collection unit. About 8 to 12 nozzles are fitted to the branch tube depending upon the amount of air treated by the dust collection unit.

The cleaning water that enters through the cleaning water inlet is converted into a spray by the spray nozzles, and this spray washes away the dust accumulated on the dust collecting electrode plates. The time required for cleaning is five minutes per electromagnetic valve, and the water pressure is $3\sim6$ kg/cm^2. About $14\sim20$ ℓ/min of water is required for washing each dust collection unit, and in case there is some limitation imposed on the amount of water due to its availability or in

TABLE 1

An example of the cleaning schedule

Part cleaned	Method of cleaning	Amount of dust	
		In ordinary proportion	Relatively large (for example, Sapporo in winter)
Dust collection unit	Automatic cleaning	On saturdays or on the 10th day after the operation stops	Everyday or on every third day after the operation stops
	Taking out and cleaning	Twice a year	First Sunday of every month
Prefilter and After-filter	Internal cleaning	At the time of automatic cleaning of the dust collection unit	Everyday or on every third day
	Taking out and cleaning	Twice a year	First sunday of every month
Exhaust water pipe and receiver	Manual cleaning and washing	Once every month	Twice every month

case there is restriction on the amount of water to be used during each cleaning operation, then the washing operation should be properly allocated to keep within the limit of the amount of water determined beforehand by mutual consultation at the negotiation stage, and the operation should be carried out starting from the top nozzles or the side nozzles and then switching on the adjacent nozzles automatically with the help of the electro-magnetic valves and ending up at the bottom nozzles or at the nozzles on the other side.

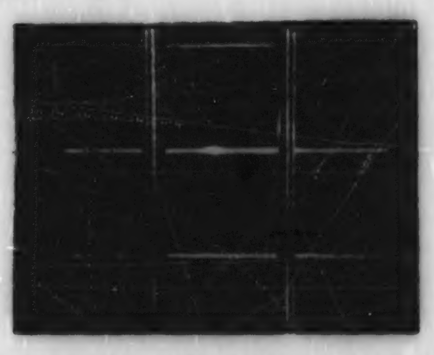

Photo 7. Washing mechanism of the frame assembly type electrical air cleaning device.

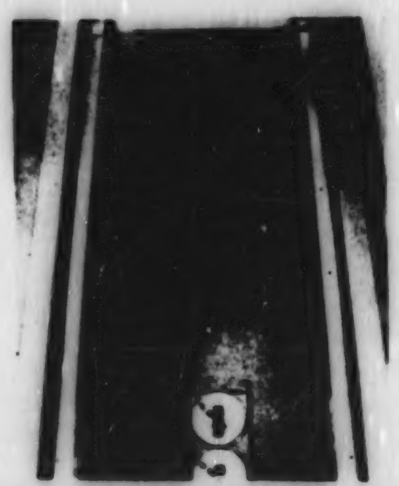

Photo 8. Washing mechanism of the cabinet type electrical air cleaning device.

4-2. Inspection, Washing, and Cleaning

The items covered by inspection and maintenance when the electrical air cleaning device is in actual running condition are the power source, state of the discharge wire, and the wiring connections etc. in the electrical system, and the gap between the dust collecting electrode plates, state of contamination of the prefilter, after-filter and the water exhaust section, and the state of the spray produced by the nozzles of the automatic cleaning section etc. in the mechanical system. Since the inspection of the items related to the electrical system can be judged daily from the state of working of the device, the inspection and maintenance mainly involves the items belonging to the mechanical system. These will be discussed below. The inspection and maintenance here primarily involves the after treatment of the dust collected and the residual dust remaining after the normal cleaning.

(1) Washing and cleaning of the dust collection unit

When the electrical air cleaning device works for long hours every day, then there occurs adherence of dust at the corner of the frame of the dust collection unit and on the surface of the high voltage glass etc. even when the routine automatic cleaning operation is carried out once in two or three days. Hence, it is necessary to dismantle the dust collection unit from the main device periodically on the basis of the cleaning schedule drawn up beforehand, and clean away the accumulated dust with the brush provided for the purpose. As the dust collection unit plays the vital role of collecting the dust, extreme care should be taken to ensure that no deformity is imparted to the dust collecting electrode plates, or that the gaps in between the electrodes are not tempered with, or that the tension of the discharge wire is left undisturbed at the time of washing and cleaning.

(2) Cleaning the prefilter and the after-filter

The prefilter fitted on the air inlet side accumulated diverse types of large and small dust particles, paper fragments, fibers and insects etc. when used over a prolonged period. When the contamination of the prefilter with these becomes too high, the prefilter should be taken out along with the afterfilter and the accumulated contaminates should be washed away thoroughly with water.

Photo 9. Dismantling the dust collection unit (frame assembly type).

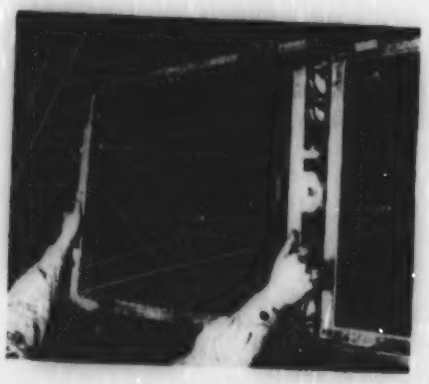

Photo 10. Dismantling the dust collection unit (frame assembly type).

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best available copy.

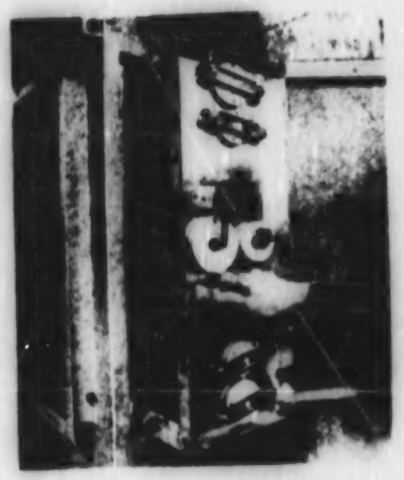


Photo 11. Dismantling the dust collection unit (cabinet type).

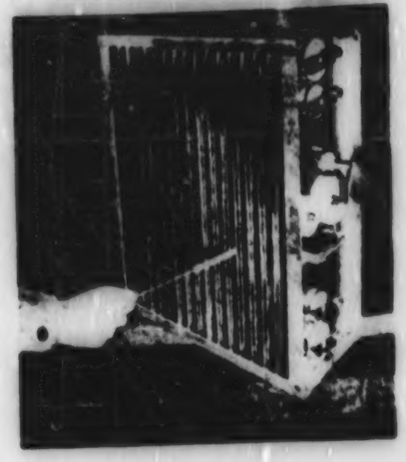


Photo 12. Cleaning the dust collection unit after dismantling.

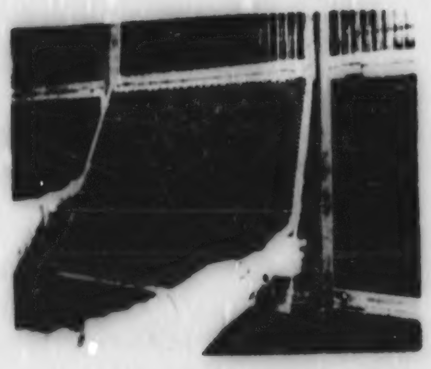


Photo 13. Dismantling the prefilter (frame assembly type).

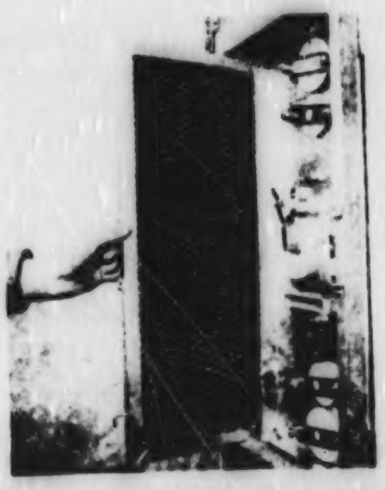


Photo 14. Dismantling the prefilter (cabinet type).

Photo 15. Dismantling the prefilter (cabinet type).

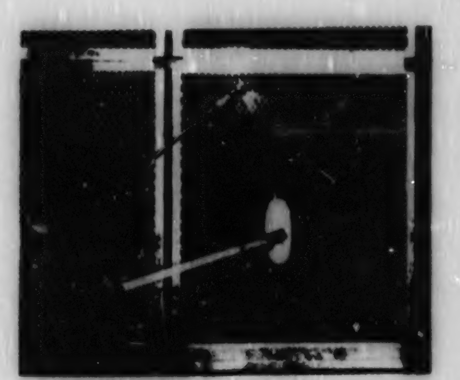


Photo 16. Washing the prefilter with water.

(3) Cleaning the water exhaust section

The dust washed away from the dust collecting electrode plates and the other parts during automatic cleaning quite often accumulates in the water exhaust section. The reason for this can be traced to inadequate slope provided at the time of installation for the drainage of the exhaust water. When the dust thus accumulated in the exhaust section dries up, it is carried by the air into the rooms. Thus, after every automatic cleaning, care should be taken to wash away the dust accumulated in the water exhaust section without fail with the help of the built in manual cleaning hose.

(4) Inspection of the washing nozzle

As the opening of the nozzle is very small, of the order of about 0.5 mm, it gets clogged readily if bad quality water is used for washing. Hence, the state of the spray should be observed at the time of automatic cleaning, and if any abnormality is noticed, immediately the nozzle should be taken out from the pipe, the screws etc. should be taken out and the necessary restoration work should be carried out.

Photo 17. Manual cleaning hose.

4-3. Repairs

No especial repair is needed when the device is used for a short length of time. However, if the device is operated continuously for three to five years, the discharge wire often snaps due to corrosion under the action of SO_2, and the insulation of the high voltage glass deteriorates or gets damaged. In such cases it becomes necessary to replace the discharge wire and the high voltage glass.

Again, accidents like burning of the high voltage transformer or puncture of high voltage condenser etc. occur rarely in the electric circuit.

It is preferable to entrust the repair of the above damages to the manufacturer. However, the following procedure should be followed if the repair is carried out by the employed maintenance staff.

(1) Changing the discharge wire

First of all, the snapped discharge wire should be removed carefully and totally from the discharge wire holders. Next, the book at one end of the new discharge wire should be attached to the discharge wire holder on the top, and other end of the discharge wire should be attached to the bottom discharge wire holder by lightly bending the bottom discharge wire holder. When the bottom discharge wire holder is released, the discharge wire will get stretched being pulled by the two discharge wire holders.

While fixing the discharge wire, care should be taken to ensure that the wire remains parallel to the dust collecting electrode plates. Again, the gap left at the top and at the bottom should be uniform with respect to the frame of the dust collection unit.

(2) Changing the high voltage glass

It becomes necessary to change the high voltage glass when the insulation resistance drops to a value below 100 MΩ or when the glass gets damaged. In such a case, the dust collection unit is taken out of the device proper, the nuts, the conduction fittings and the short circuit switch etc. of the high voltage glass are detatched, the glass is carefully taken out and the new one is placed back, and then the nuts etc. are tightened. Here, care should be taken to ensure that the gap in between the electrodes is not tempered with.

In case any other part not connected with the high voltage glass is detatched, then the assembly back usually becomes extremely difficult. For example, if the coupling bolt is taken off, then all the gap tubes maintaining the gaps in between the dust collecting electrode plates come off. Hence, good care should be taken at the time of replacing the glass.

Again, when changing the high voltage fixed glass provided on the side of the device proper for automatic connection of the dust collection unit, care should be taken to connect the two lead wires, a 7.5φ wire for high voltage electrode impressing (can withstand up to 20 KV) and a 5ϕ wire for intermediate electrode impressing (can withstand up to 7.5 KV), properly. Any wrong connection of these two wires renders the dust collection impossible.

(3) Repair due to electrical abnormality

Sometimes repairs become necessary due to electrical faults. The faults, their causes and the remedial steps for setting the faults right have been shown in Table 2.

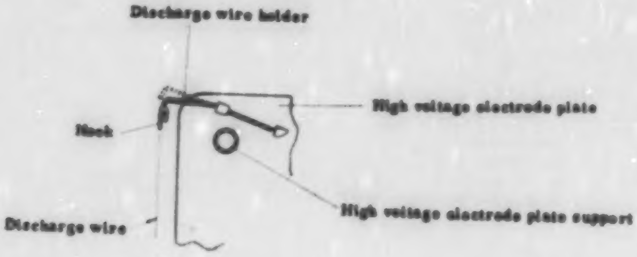

Discharge wire holder
High voltage electrode plate
Hook
High voltage electrode plate support
Discharge wire

Fig. 1. Fixing of the discharge wire.

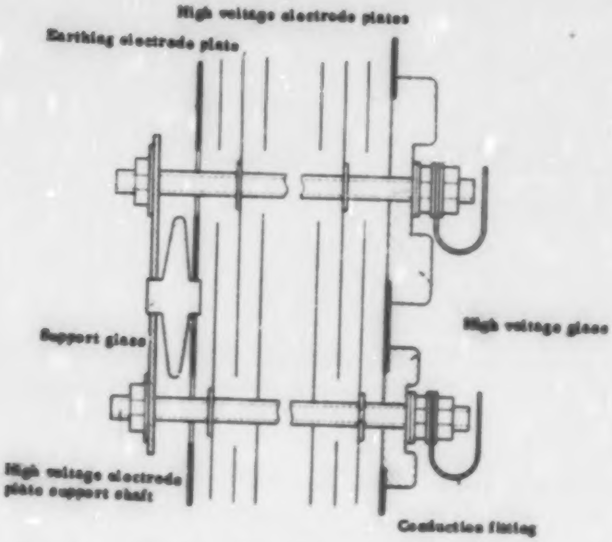
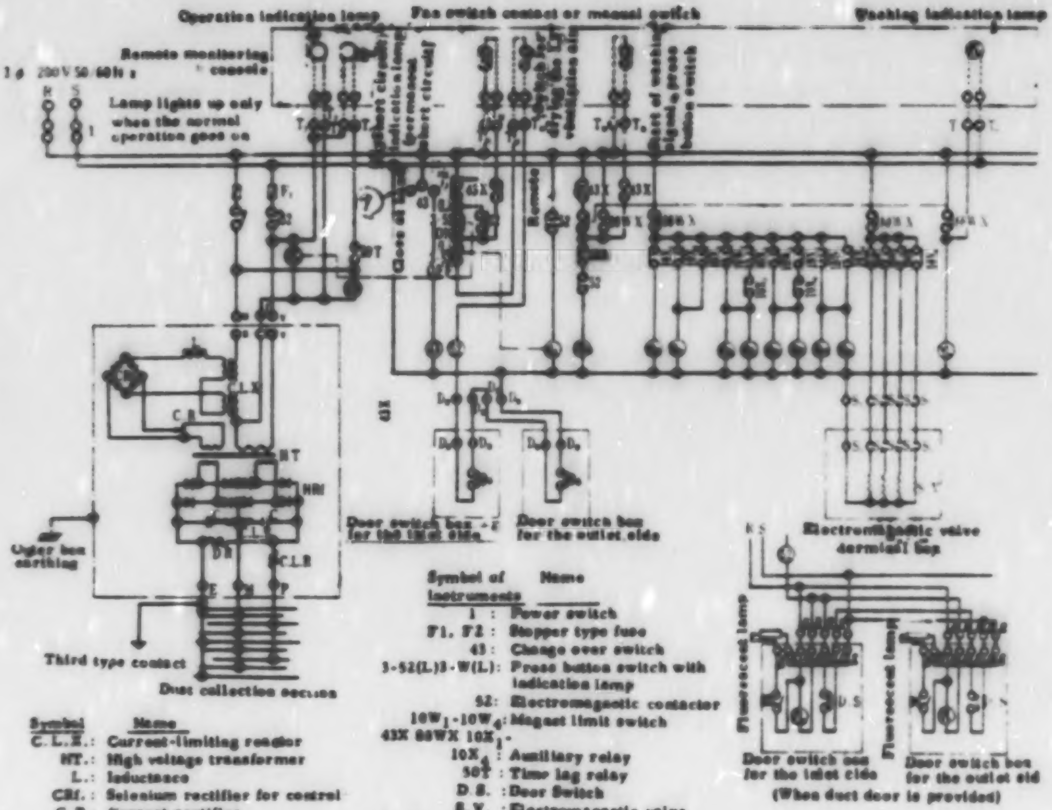

High voltage electrode plates
Earthing electrode plate
Support glass
High voltage glass
High voltage electrode plate support shaft
Conduction fitting

Fig. 2. Fitting of the high voltage glass.


Operation indication lamp
Fan switch contact or manual switch
Washing indication lamp
Remote monitoring console
1φ 200V 50/60Hz
R
S
Lamp lights up only when the normal operation goes on
Close of door
Remote
Start of washing
Signal press button switch
Door switch box for the inlet side
Door switch box for the outlet side
Electromagnetic valve terminal box
Outer box earthing
Third type contact
Dust collection section
C.L.X
C.R
HT
HRf
CLR
DR
Fluorescent lamp
Door switch box for the inlet side
Door switch box for the outlet sid
(When duct door is provided)

Symbol	Name
C.L.X.:	Current-limiting reactor
HT.:	High voltage transformer
L.:	Inductance
CRf.:	Selenium rectifier for control
C.R:	Current rectifier
HRf:	High voltage silicon rectifier
C:	High voltage condenser
DR:	Discharge resistance
C.L.R.·	Current limiting resistance

Symbol of Instruments	Name
1 :	Power switch
F1, F2 :	Stopper type fuse
43 :	Change over switch
3-52(L)3-W(L):	Press button switch with indication lamp
52:	Electromagnetic contactor
10W$_1$-10W$_4$:	Magnet limit switch
43X 88WX 10X$_1$-10X$_4$:	Auxiliary relay
50T :	Time lag relay
D.S. :	Door Switch
S.V. :	Electromagnetic valve
BL GL YL PL:	Indication lamp
KL:	Tumbler switch

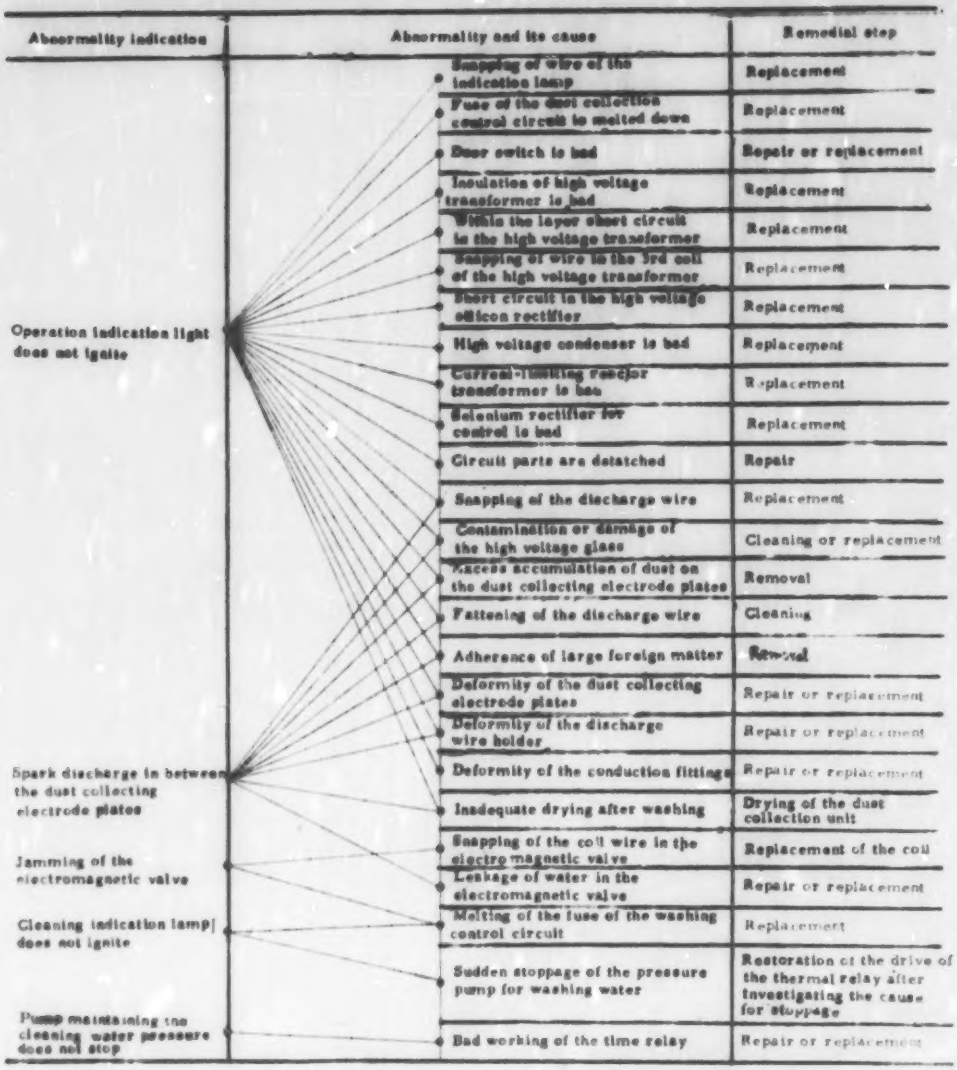
Literature

1. Taiki Osen Kenkyu Zenkoku Kyōgikai: Jojin Sōchi Hando Bukku (Handbook of Dust Removing Equipment), Korona Co. (1963) 220.

2. Kenchikubutsu Eisei Kanri Kijun (An) (Standard for Maintaining Hygienic Environment inside the Buildings (Draft)),· Koseisho.

TABLE 2

Electrical abnormalities, their causes and the remedial steps



Abnormality indication	Abnormality and its cause	Remedial step
	Snapping of wire of the indication lamp	Replacement
	Fuse of the dust collection control circuit is melted down	Replacement
	Door switch is bad	Repair or replacement
	Insulation of high voltage transformer is bad	Replacement
	Within the layer short circuit in the high voltage transformer	Replacement
	Snapping of wire in the 3rd coil of the high voltage transformer	Replacement
	Short circuit in the high voltage silicon rectifier	Replacement
Operation indication light does not ignite	High voltage condenser is bad	Replacement
	Current-limiting reactor transformer is bad	Replacement
	Selenium rectifier for control is bad	Replacement
	Circuit parts are detatched	Repair
	Snapping of the discharge wire	Replacement
	Contamination or damage of the high voltage glass	Cleaning or replacement
	Excess accumulation of dust on the dust collecting electrode plates	Removal
	Fattening of the discharge wire	Cleaning
	Adherence of large foreign matter	Removal
	Deformity of the dust collecting electrode plates	Repair or replacement
	Deformity of the discharge wire holder	Repair or replacement
Spark discharge in between the dust collecting electrode plates	Deformity of the conduction fittings	Repair or replacement
	Inadequate drying after washing	Drying of the dust collection unit
	Snapping of the coil wire in the electromagnetic valve	Replacement of the coil
Jamming of the electromagnetic valve	Leakage of water in the electromagnetic valve	Repair or replacement
Cleaning indication lamp does not ignite	Melting of the fuse of the washing control circuit	Replacement
	Sudden stoppage of the pressure pump for washing water	Restoration of the drive of the thermal relay after investigating the cause for stoppage
Pump maintaining the cleaning water pressure does not stop	Bad working of the time relay	Repair or replacement

Standard for Maintaining Hygienic Environment inside the Buildings (Draft)

1. Environment related to air

	Standard of maintenance	Method of measurement etc.
(1) Air temperature	The temperature of the air within the range 17-28°C. However, the following specifications should be followed when cooling or heating of the building is carried out. (a) the indoor temperature should be in between 22° and 28°C when cooling and the difference with the outside temperature should be below 7°C on principle (b) The indoor temperature should be in between 17° and 25°C when heating.	Measurement should be carried out at one spot per 100m^2 floor area. Two measurements should be carried out at two points, 30 cm and 1 m above the floor and one just above the other, at every spot, more than one day every week (three times, at 9 A.M., 12 noon and 3 P.M.). The arithmetic mean of the values at the two vertical points is taken.
(2) Humidity	The relative humidity inside the room should be within the range 50∼80%.	Measurement procedure laid down in 'Air Temperature' section should be followed.
(3) Air current	(a) The speed of air flow should be below 25 cm per second when cooling. (b) The speed of air flow should be below 30 cm per second when heating. (c) At the time of artificial ventilation nobody should be accommodated within a radius of 2 m of the push and the pull openings.	Measurement procedure laid down in 'Air Temperature' section should be followed.

(4) Ventilation	Ventilation with fresh outside air should be carried out at the rate of above 30 m^2 per hour per person accommodated in the building. However, if the air conditioner possesses adequate performance, then up to 2/3rd recirculation air can be used.	Measurements according to the methods prescribed in JIS B 8330 should be carried out more than once a month at the push and the pull openings.
(5) Microorganisms	The number of the precipitating microorganisms should be less than 75 individuals.	Measurement should be carried out more than once every month (at 3 PM) at one spot (75 cm above the floor) per 100 m^2 floor area. Petri dish (9 cm inner diameter) containing agar agar plate medium is left undisturbed for 5 min at the spot of measurement, and then cultured for 48 hours in an incubator at 37°C. The number of microorganisms colonies appearing here is taken as the number of the precipitating microorganisms.
(6) Dust	The amount of dust should be below 0.2 mg per m^3 of air.	Measurements are carried out more than once every month (3 P.M.) at one spot (75 cm above the floor) per 100 m^2 floor area, using filter paper dust gauge.
(7) Injurious gas	Carbon monoxide should be below 10 ppm, sulfur dioxide below 0.1 ppm, and carbon dioxide below 1000 ppm.	Measurements should be carried out at one spot (75 cm above the floor) per 100 m^2 floor area, more then once every month (3 P.M.) in the cases of carbon monoxide and sulfur dioxide, and more than once every week (11 A.M.), in the case of carbon dioxide. Gas detection tube method is followed for carbon monoxide and carbon dioxide, and rosaniline method for the sulfur dioxide.

Contd.

1	2	3
(8) Equipment management	(a) Cooling and heating devices as well as other equipment producing injurious gases should not be used unless they are provided with suitable mechanisms for removing the injurious gases thus produced outside the building. (b) The air should be cleaned with the help of an air cleaning device while carrying out air conditioning. (c) The dust collection efficiency (gravimetric method) of the air cleaning device should be above 85%. (d) When air filter is used, the resistance to air of the air filter should be monitored constantly by providing pressure gauges (manometer) that will indicate the pressure difference before and after the air filter. (e) When heating or cooling water coil or temperature adjustment device and humidity regulating device are used, the state of their superficial contamination should be watched constantly, and a very thorough inspection should be carried out periodically more than twice a month. (f) The other equipment of the air conditioning system besides those mentioned above should be cleaned and adjusted more than twice a year.	
2. Illumination		
(1) Intensity of illumination	The following intensity of illumination should be maintained at the different sections of the building depending upon their uses. (a) 300～700 Lux in the case of office rooms, automatic control rooms and telephone exchange rooms etc.	Depending upon the use, measurements should be more than once a month at more than one spot (at the horizontal plane at a height of 75 cm above the floor) per 500 m^2 of floor area.

	(b) 150~300 Lux in the case of conference rooms, assembly halls, dining halls, waiting rooms, washing places, cloak rooms and similar places. (c) 70~150 Lux in tea rooms, staircases, cloak rooms, porch and similar places. (d) 30~70 Lux in the emergency staircases and similar places.	
3. Supply and drainage of water		
(1) Quality of water	The water to be used for drinking purpose should conform to the conditions prescribed in Article 4 of the Tap Water Act.	Measurements are carried out according to the methods given in the Appendix of the government ordinance on the Water Quality Standard.
(2) Management of the water supply facilities	(a) The measures prescribed in Article 22 of the Tap Water Act should be implemented. (b) Periodic checkup, sepair and cleaning of the storage tank should be carried out more than twice a year. (c) The water supply pipes and the shafts for the pipe layout should be examined constantly in order to detect corrosion, and leakage etc. (d) Check-up and repair of the pump should be carried out periodically. The pump room also should be cleaned properly and periodically.	

Contd.

(3) Management of the drainage facilities	(a) Substances which are likely to interfere with the disposal of the polluted water by clogging, or by damaging the drainage system or substances which are likely to produce explosive mixtures should not be allowed to find their way into the water drainage system. (b) The drainage pipes opening into the kitchen should be cleaned more than once a month. (c) The exhaust pump should be checked periodically more than twice every year and the necessary repairs should be carried out. (d) The drainage tank should be checked periodically more than twice every year and the necessary repairs and cleaning should be carried out.

4. Cleaning and elimination of rats etc.

(1) Disposal of the dirt and wastes	(a) Lids should be provided to the containers or the carriages used for transporting the dirt and other wastes. (b) The location of the place for dumping the dirt should be designed carefully so that it does not have any adverse effect on the environmental hygiene. (c) The place for dumping the dirt should be provided with compartments for dumping the wastes from the kitchen and other places separately, and should be managed properly so that there is no adverse effect on the environmental hygiene.

	(d) The place for burning the wastes should be designed carefully so that the burning does not affect the environmental hygiene adversely. (e) The sewage treatment facility should be managed according to the specifications laid down in the Articles 9 and 10 of the Ordinance on Enforcing the Cleaning Provisions.	
(2) Elimination of the rats, mice and the insects	Extermination of rats, mice, flies and mosquitoes should be carried out once in spring and once in autumn. Extermination of Gokiburi should be carried out periodically once every two months, six times a year.	The extermination should be carried out according to Sections 4 and 5 of Article 27 of the Ordinance for Enforcing Steps for Preventing the Infectious Diseases.

MAINTENANCE AND SUPERVISION OF THE AUTOMATIC AIR CLEANING DEVICES

S. MATSUZAKI

I. Introduction

The various types of injurious dust and gases produced in everincreasing proportion by the various manufacturing processes with the recent rapid expansion of the industrial activities are not only affecting our day to day social life, but also are damaging the mechanical and electrical equipment and instruments, quite often rendering the manufacture of precision products rather difficult. In short, the pollution is becoming more and more grave with the every passing day.

Of the dust particles floating in the atmosphere, those in the range of 5∼30 μ account for about 80% of the total in terms of weight, and the dust of size below 10 μ constitute the overwhelming majority in terms of population.

Various types of air cleaning devices have already been developed or are under study at present in order to remove the above dust as demanded by the various processes of manufacture. However, the cardinal requirement in the efficient operation of the air cleaning devices involves proper check-up and maintenance of the devices.

The air cleaning devices can broadly be divided into two types, the unit type and the automatic type. The present paper will be devoted to the maintenance and management of the automatic type, leaving the discussion on the unit type to a future occasion.

II. Types of Air Cleaning Devices

The air cleaning devices can be divided into three types on the basis of the principle of their working, viz., filter type, electrostatic type and impact adhesion type. These three types will be discussed individually below.

(1) Filter type

The filter here consists of glass fiber or non-woven fabric of synthetic fiber like Tetron, nylon etc., or special type filter paper. The filter is wound automatically, and fresh filter is introduced with the help of a timer or a pressure switch.

(2) Electrostatic type

Of the three types of the air cleaning devices, the filtering efficiency of this type is the highest. The electrostatic type, however, can be further subdivided into the following four sub-types.

(a) Those where the dust collecting electrode plates are wound while passing the electricity and being washed automatically.

(b) Those where the dust particles are collected and enlarged on the dust collecting electrode plates, and then captured finally with the help of filters made of glass fiber or some such material. This filter is wound automatically.

(c) Those where the dust accumulated on the dust collecting electrode plates is washed periodically with the help of water or warm water when the operation is over.

(d) Those where the dust is adsorbed on dielectric filter made from synthetic fiber that gets electrified readily. The filter is then wound up.

(3) Impact adhesion type

A film of sticking oil is formed on a metallic screen wound on an endless chain, and the screen is rotated and washed automatically with the help of a timer. The filtering efficiency is somewhat lower, but since the structure is very simple and strong, it proves very effective in places with high dust concentration.

III. Maintenance and Supervision of Automatic Type Air Cleaning Device

(A) Filter Type

As has already been stated it is driven by two types of mechanisms, timer and pressure switch. However, in certain devices, both the mechanisms are used simultaneously.

(1) When pressure switch is used

(1-1): The pressure detection tube is cleaned from time to time, and it is ascertained whether the tube is registering the pressure correctly or not.

(1-2): The service door should not be opened when the air is in circulation. In the absence of any especial electrical provision, the working of the device may be accompanied by acute variation in pressure which may not be related to the clogging of the filter.

(1-3): It is necessary to modify the values for operation during the heating or cooling or during the intermediate period depending upon the location of the pressure detection tube.

(2) When timer is used

The variation in resistance should be studied by recording the readings of the pressure difference gauge especially provided for the purpose, and in case any abnormality is detected in the trend, then readjustment should be carried out.

(3) Changing the Filter

When the filter is wound up completely, the end-of-winding switch cuts off the operation circuit automatically. At this instant the light indicating the end of winding of the filter ignites or the buzzer rings. However, the filter can be used for a few days even after the signalling of the warning, so there is no need to hurry with its immediate replacement. Even when the end-of-winding switch works, the filter remains over the whole duct cross section.

At the time of changing the filter, the filter should be wound up completely on the spool with the help of the manual switch, and then should be removed together with the spool. Next, the other spool which has become empty is placed in the position of the spool which has been removed. As the pins provided at the two ends of the spool which is removed are used over and over again, they should be carefully taken out from the spools at the time of its removal, and then used again for fixing the new spool in position.

(4) Drive mechanism

(4-1): The motor and the reduction gear should be lubricated once in a year.

(4-2): If V-belt is used, then it should be checked periodically, and proper degree of tightening should be done depending upon the necessity.

(4-3): The moving parts should be greased once or twice a year depending upon the necessity.

(B) Electrostatic Type

This type bears no relation with the type mentioned above. The inspection and maintenance should cover the following points.

(1) The working of the automatic control circuit and the safety mechanisms like the door switch etc. should be checked.

(2) The prefilter should be maintained properly in order to check the introduction of large sized dust into the dust collection section. In case a large sized particle gets stuck up on the electrode plates, then short circuit follows bringing down the efficiency.

(3) The insulation glass should be cleaned at least [illegible]ice in every six months.

(4) Whether the high voltage generation mechanism supplies the normal high voltage or not should be checked from time to time.

(5) Again, the following points should be covered in the automatic washing models.

(5-1): The wipers, both moving and fixed, should be checked up once in every six months in order to determine their qualitative deterioration and wear and tear.

The fixed electrode plates should be examined immediately after the movement of the moving wiper in order to ascertain whether the electrode plates have been cleaned uniformly or not. The opposite checkup should be carried out with the fixed wipers.

(5-2): The sludge accumulated inside the oil tank should be cleaned periodically. The interval of cleaning depends upon the performance of the prefilter and the amount of dust carried by the incoming air. Here the time required for the sludge to accumulate to a height of 40 mm is measured, and this time is taken as the interval for cleaning the oil tank.

(5-3): Extreme care should be taken to use only the specified oil. Care should also be taken to add oil from time to time so that the level of the oil inside the tank remains at the level mark given inside the tank.

(5-4): Care should be taken to ensure that the rotating parts keep on moving uninterrupted even when the fan feeding the air is stopped temporarily or the circuit of the high voltage side is cut off. (This is necessary for ensuring that the dust collecting electrode plates remain covered with oil film always).

(6) For periodic cleaning model

(6-1): The sticking oil should be kept sprayed on the dust collection section. This is necessary for preventing reentrainment of the dust already collected.

(6-2): Adequate pressure should be maintained at the spray used for washing.

(6-3): After washing, the device should be operated in dry state prior to switching on the power.

(6-4): Only those types of sticking oils specified by the manufacturer should be used.

(6-5): Proper check-up should be carried out for leakage in the nozzles, strainer and the electromagnetic valves. The state of the washing water system and the running gear used for washing should also be examined.

(6-6): The state of the water drainage system should be examined.

(7) For the two step charged automatic winding model and the dielectric model, the items specified for the 'Filter type' and the items (1) - (5) mentioned above should be taken for reference.

(8) Again, the following points of general nature should also be covered.

(8-1): The following reasons can be given for the supply of lower voltage from the high voltage generation section.

(a) Here either the primary voltage supplied to the high voltage generation section is lower than the rated value, or the tap has been set at a value lower than the primary voltage. In such cases the secondary voltage can be raised by changing the tap setting so long the high voltage generation section does not gets its total load.

(b) When an unusual large current flows through the dust collection section, the cause can be attributed either to the soiling of the glass, or to the use of some non-specified sticking oil, or to the excess accumulation of dust, or to the damage of the insulator.

(8-2): On short circuit: The short circuit arises mostly due to the following causes.

When the tungsten wire ionizer snaps and gets earthed.
When some metallic piece gets stuck up in the dust collecting electrodes.
When the electrode plates get twisted or touch each other.
Some defect inside the high voltage generation section.

(a) First of all the ionizing circuit and the dust collecting electrode plate circuit should be checked. The lead wires of the dust collecting electrode plates inside the high voltage generation section be disconnected, and if there is no short circuit, then the cause should be searched elsewhere.

(b) If short circuit is still there, then the lead wires of the ionizer are removed and checked. If there is no short circuit here, then it is to be searched in the ionizer circuit.

(c) If the short circuit persists even when both the lead wires are removed, then the fault lies in the high voltage generation section itself.

(i) In case a single high voltage generator charges more than one ionizer, and if the voltage in one of the ionizer is lower than that in the others, it indicates that the connection with the high voltage power has not been done properly.

(ii) In case the voltage in the dust collecting electrode plates is lower than the specified value, then the cause can be traced to item 7-(1)-(a) above. However, if the voltage in the ionizer and in the dust collecting electrode plates, is higher than the rated value, then the cause can be found either in the snapping of wire in the ionizer circuit, or in too high primary voltage, or in improper tap setting in the high voltage generating section.

(8-3): Sudden fluctuation in the temperature of the air stream produces deformity in the electrode plates which in turn affects their performance. Hence good care should be taken on this score.

(8-4): The cause for the smell of ozone can be found in excess primary voltage; and in such case abnormal discharge takes place in the ionization section from the projections provided on the ionizer or brush discharge takes place in between the dust collecting electrode plates.

(8-5): Care should be taken not to change the volume of air treated abruptly.

(C) Adhesion Impact Type

This type is very similar to the automatic washing model discussed in the Section (B) above.

(1) Inspection of the cleaning oil

The amount of oil inside the oil tank is examined, and fresh oil is added upto the oil level marked on the side of the tank. If the level of oil falls below the level marked on the side of the tank, then the dust removal efficiency deteriorates rapidly.

(2) Cleaning within the chamber

Not only for this type, it is important to keep the inside of the chamber clean for all types of air cleaning devices. If the interior of the chamber remains dirty, then all the dirt gets stuck up on the screen as soon as the operation starts causing trouble.

(3) The direction of rotation should be checked properly.

(4) Periodic check-up of the oil tank (removal of the sludge)

If there is an excess accumulation of sludge inside the oil tank, then the sludge cleaned out from the dust collection screen will be circulated again on the screen along with the oil. Thus, the periodic checkup of the oil tank should not be neglected. The latest models of the industrial dust removing devices, however, have built in ejector for removing the sludge from the oil tank.

(5) Filtering the oil

It is desirable to filter the oil inside the oil tank once or twice a year. It is also desirable to provide a special oil cleaning mechanism in the large capacity air cleaning devices.

(6) The oil is blown out and dispersed if the speed of the air stream is too high or erratic. The distribution of the air speed, thus, should be checked up carefully.

(7) Water should never be put inside the oil tank even by mistake as this brings down the filtering efficiency.

(8) It is desirable to keep the screen rotating even when the air supply is stopped as formation of the oil film on the screen is of paramount importance.

If the rotation of the screen is stopped by chance, then effectiveness will be very low immediately after the restoration of the air supply as the air film formation will not be adequate.

(9) It is necessary to clean the screen once in a number of years the timing being determined by the dust content of the air treated.

(10) Again, care should also be taken on the following mechanical points.

(a) Whether there is any abnormality in the working of the rotating parts namely the driving motor and reduction gear etc. or not.

(b) Whether the timer is working as rated or not.

(11) Only the oils specified by the manufacturer should be used.

(12) The parts responsible for driving e.g. the motor and the reduction gear etc. should be lubricated periodically without fail.

IV. Conclusion

A discussion on the maintenance and management of the automatic air cleaning devices has been carried out above in brief, and in the end the author would like to emphasize once again the importance of maintenance of the air cleaning devices irrespective of whether they are of automatic type or of unit type, so that they can successfully discharge their vital function in checking atmospheric pollution, an acute social issue, which is aggravating in leaps and bounds with the rapid developments in the industrial scene of the nation.

AIR FILTERS

Type	Maintenance	Typical brand name	Mechanism	Granularity for which used (μ)	Dust concenteration	Efficiency (%)	Resistance (m/m Aq)	Scope of application
1	2	3	4	5	6	7	8	9
Electrostatic type	Automatic washing type	for example; Electromatic	Two step electrical dust collector. Automatic washing is done by rotating the dust collecting electrode plates	Below 1	Small	85~90 (Decoloration method)	8.5	Removal of fine dust particles used in ordinary industries, precision industries & air conditioning
	Periodic washing type	for example: Electrocell; Clean air; Air cleaner	Two step electrical dust collector. The dust collecting electrode plates are washed periodically	-do- -do- -do-	-do- -do- -do-	-do- -do- -do-	8	-do- -do- -do-
	Media exchange type	for example Electre FL	One step electrical dust collector. Special type filter paper is used which is replaced by fresh one	-do-	-do-	80 (Decoloration method)	3~20	-do-
	Automatic winding type	Roll o-tron; Electroil	The dust aggregated on the dust collecting electrode plates is captured by glass filter. Dust is adhered on synthetic fiber by creating a statical electrical field on it.	-do- -do-	-do- -do-	90 (Decoloration) 70 (Decoloration)	9~12 -do-	-do- -do-

Contd

1	2	3	4	5	6	7	8	9
Filter type	**Automatic washing type, Automatic winding type**	**Roll-o-matik,**	Specially treated glass medium is used. Automatic winding.	Above 1	Large	90 (gravimetric method)	8.5∼125	For air conditioning the factories and buildings.
		Auto air mat,	Specially treated filter paper is used. Winding by air resistance	Above 3	-do-	90 (gravimetric method)		For removing lint of spinning mills and mist in printing works
		Auto roll	Nylon is used as the medium. Winding & washing type	Above 3	Medium	85 (gravimetric method)	8∼12	For airconditioning buildings
	Periodical washing type	**Moltopren filter**	Specially prepared polyurathane film which can be washed and used over again	Above 3	Medium	80 (gravimetric method)	3	For small sized air conditioners
	Media exchange type	**Air mat PL-24.**	Specially processed filter is used which is exchanged with fresh one.	Above 1	Medium	95 (Gravimetric method)	3∼15	For air conditioning the factories and buildings.
		Deep head.	Pocket sized type with glass fiber as the medium. The medium is replaced by fresh one	-do-	Small	85 (Decoloration method)	3∼25	For using in precision machine factories.
		NS filter	Pocket sized type using cotton as the medium. The medium is replaced by fresh one	-do-	-do-	80 (Decoloration method)	3∼15	For air conditioning the Spinning mills
	Unit exchange type	**Dry pack**	Special pocket type with glass fiber as the medium	Below 1	Small	95 (Decoloration)	3∼25	Precision machine & photography industries.
		Amaglass	Unit type using specially processed glass medium	Above 3	Medium	80 (gravimetric method)	3∼10	For small capacity air conditioners
		Astrocell filter	Unit type containing V shaped specially processed glass medium.	Below 1	Small	Above 99.9 (calculation method)	20∼50	For removing radioactive dirt

Impact adhesion type	Automatic washing type	Multi duty; multi panel	Oil film is produced on the wire screen or plate screen which is rotated and washed automatically	Above 3	Large	80 (gravimetric method)	12	For ordinary air cleaning
				Above 5	-do-	75 (gravimetric method)		-do-
	Periodic washing type	M/W air filter;	Unit type with overlapping buffer and wire screen	Above 3	Large	85	5~10	For ordinary outside air.
		H/V air filter;	Unit type with overlapping triangular spindle shaped wire screen	Above 5	-do-	70 (Gravimetric method)	3~6	Air cleaner for vehicles.
		Grease filter;	Unit type with overlapping metallax netting	-do-	-do-	80	3~10	For cleaning exhaust air containing oil for example exhaust air from kitchen.
		Vinirok	Unit type using treated synthetic fiber of Vinylidine group	Above 3	Medium	80	4~10	For ordinary building air conditioners
	Media exchange	Renyuglass	Unit type using specially processed glass medium	Above 3	Medium	80 (gravimetric method)	3~10	For small capacity air conditioners.

MAINTENANCE AND MANAGEMENT OF THE AIR CLEANING DEVICES IN THE OFFICE BUILDINGS

N. KASAHARA

1. Introduction

The rapid development of the industries in the recent years has brought about the problem of pollution in the urban areas affecting the day to day life of the people living there. Consequently, the question of cleaning of the outside air while introducing it into the air conditioners has become a very important issue in the field of architecture as well.

Especially, since the proper management of the air cleaning device (air filter) exerts a great influence on the indoor climate inside the office buildings, the scope of the present paper will be restricted to the maintenance and management of the air cleaning device, which constitutes a very important part in the air conditioners.

2. Object of Management of the Air Filter

The object of management of the air filter is to supply clean air after removing the injurious substances from the outside and indoor air (like sulfur dioxide, carbon monoxide, hydrogen sulfide, carbon dioxide, anhydrous sulfuric acid and hydrocarbons etc.) so that the people living inside do not face any health hazard, on account of air. This involves technical management of the air filter by carrying out daily routine check up and cleaning in order not to allow the performance of the air filter to deteriorate (brought about by adherence and accumulation of the injurious substances).

3. Management Operation

As has been stated above, the daily routine check-up and cleaning constitute the most important aspects in the maintenance of the air filters, and hence the points where proper attention should be paid while carrying out the above operations will be discussed below.

Air filters provided to the air conditioners and the air circulators come in diverse types, and the air filters commonly used in the buildings belong to the following categories.

1) Electrical dust collectors

The electrical dust collectors have become extremely popular in recent years, and the buildings erected recently have installed these without exception. Here, prefilter (unit type or multipanel type) is provided at the inlet of the outside air or on the outside air introduction side for capturing the contaminants of the outside air. However, since gases like sulfur dioxi-dioxide can pass through the air filter, the prospect of using the air cleaning device simultaneously should be studied as a countermeasure. Care should be taken regarding the following points for managing the electrical dust collector properly.

(1) The volume of air passing should not cross the permissible limit.

(2) Dust should not be allowed to accumulate in excess amount in the dust collection section.

(3) Intrusion of the foreign matters into the dust collection unit should be checked. For example, if large amount of water drops find way into the dust collection unit, the insulation of the high voltage glass will deteriorate posing the danger of discharge. As a preventive step, either a prefilter or a metallic screen (20 ~ 30 mesh) should be provided on the air inlet side.

(4) The electrode plates used for collecting dust are usually made of very thin sheets as a result of which their thermal capacity is very small. Thus, care should be taken to prevent abrupt rise in the speed or temperature of the air current. (Thermal distortion appears in the electrode plates because of difference in expansion of the electrode plate supports as well).

(5) The increase in frequency of the sparks (producing bluish light) using the dust accumulated on the dust collection unit as the medium results in a lowering of the efficiency of the unit as well as a shortening of the life of the rectifier tube of the power source. Hence, good care should be taken to check the state of accumulation of dust in the dust collection section.

2) Multipanel air filter

This type of air filter is rarely used at present, although occasionally it is used along with the electrical dust collector.

(1) The state of separation of the dust adhering to the screen panel inside the oil tank is observed.

(Continued inadequate separation of the adhering dust from the panel brings down the dust collection efficiency of the panel considerably. Therefore, the panel should be cleaned periodically with the help of steam. Again, the filter oil should also be cleaned by filtering).

(2) When the degree of contamination of the filter provided at the inlet of the outside air is high consequently requiring higher frequency of cleaning, a prefilter should be provided in front of the filter (the prefilter used here is of unit panel type containing non-woven cloth filter). The frequency of cleaning of the multipanel air filter can be reduced and hence the running cost can be decreased by increasing the frequency of cleaning of the prefilter.

(3) Attention should be paid to the dust collection efficiency of the screen panel and to the pressure loss. (The pressure loss is calculated from the static pressure difference before and after the filter and from the speed of air current).

(4) The quality of the filter oil used should be checked carefully. (The essential conditions indispensible for the filter oil are: the oil should have good resistance to oxidation, it should possess high degree of stability so that no qualitative deterioration sets in during prolonged use, it should have high ignition point so that there is no danger of ignition, and it should not be volatile so that it does not evaporate so easily).

(5) Inspection doors should be provided before and after the air filter in order to facilitate inspection, maintenance and supervision of the filter.

3) Automatic winding type air filter (non-woven cloth)

(1) Since the air speed exceeding the standard air speed (2.5 ~ 3.5 M/S) brings about a deterioration in the dust collection efficiency, care should be taken not to exceed the standard air speed.

(2) The speed distribution of the air stream should be uniform. (The efficiency falls conspicuously if there is local high or low speed or eddies in the air stream).

(3) It is necessary to leave enough space before and after the air filter. [These spaces are needed for rectifying the air stream (for preventing the eddies), exchanging the filter and carrying on inspection].

4. Inspection and Cleaning

The various points requiring necessary care taken during the routine management operation have been discussed above. The methods to be employed at the time of the day to day inspection and cleaning as well as the period of cleaning will be discussed in this section.

A) On the air filter and prefilter of the outside air harmonizer:

(1) Unit type air filter (non-woven cloth)

These type of filters should be washed with detergent (synthetic detergent) or hot water, and should be dried thoroughly before using again. Thus a filter in reserve is needed to a certain extent. Inspection should be carried out twice or thrice a month, and the cleaning frequency is twice a month (The cleaning frequency is increased depending upon the mode of use of the filter).

(2) Electrical dust collector

Washing is carried out with the help of water, either hot or cold, and the adhesion agent should be applied thoroughly after proper drying. The cleaning frequency is 3∼4 times per month in the case of ordinary office building, and once everyday in the case of shops and stores.

(3) Multipanel type air filter

Steam washing is carried out in cleaning the dirt adhering to the screen panel. The dirty filter oil is used again after filtering. The oil tank is cleaned to remove the sludge adhering to the side and bottom of the tank. Activated clay or strainer should be used for filtering the filter oil. The oil thus refined by filtering should be added to the extent of 10∼15% of the total amount of oil in the tank. Cleaning should be carried out 2∼3 times a year, which can be increased if the soiling of the oil is too severe.

B) Air filters of the air conditioning systems

(1) Automatic winding type air filter

The day to day routine check-up involves checking the degree of contamination with the help of manometer, and inspection of the control panel (micromanometer, power lamp, pressure difference working indication lamp, filter exchange lamp, manual motor switch, and automatic switch). If the space for carrying out the washing operation is lacking at the site of installation, then the washing of the roll mat shaped filter material in the auto roll should be entrusted to the contractors specialized in the field. The changing and washing of the filter should be carried out 1∼2 times a year, but the frequency varies depending upon the state of soiling.

(2) Electrical dust collector

The electrical dust collectors provided to the various air conditioning systems should be cleaned according to the procedure laid down for the same used with the outside air harmonizers.

The cleaning should be carried out twice per week in the case of offices and thrice per week in the case of shops and stores. The frequency of cleaning should however be increased depending upon the trade carried out in the latter case.

(3) Multipanel air filter

The multipanel air filter used with the air conditioners installed in the basement machine room should be cleaned once in six months. The filter oil should also be refined by filtering once in six months. Steam washing of the panel and the casing should be carried out once in two years (the filter oil should be filtered during this operation).

C) Air filter of the basement air supplier (for godowns, transformer room and machine room

Air to the basement is supplied either through outside air harmonizer or through air filter. Considering from the qualitative point of view, air of the former type is preferable for the transformer rooms.

The frequency of cleaning of the filter used here should be as follows. Electrical dust collector: 3 ~ 4 times/month
Automatic winding type air filter: 1 ~ 2 times/year
Unit type air filter: Twice/month
Multipanel air filter: Once in six months.

5. Classification of the Air Filters

The classification of the air filters on the basis of their uses and the dust collection efficiency has been shown in Table 1.

6. Problems Involved in Management

The following are the problems involved in the management of the air filters.

1) Exhaust device in the restuarants and the employees dining halls

Inspection, cleaning and management of the exhaust device are usually difficult in the restaurants and employees dining

TABLE 1

Classification of the air filters

Type 1	Uses 2	Dust collection efficiency (%) 3	Remarks 4
Electrical dust collector	Ordinary buildings, electronic computer room, operation theater, and medicine factory.	60~90 (Above 1μ)	It is composed of an ionizer and a dust collection unit. The dust collection unit is made from aluminum highly resistant to corrosion. It is very effective against soot, dust and urban pollution, and is indispensible for ordinary buildings.
Unit type air filter (copper wool)	Ordinary buildings and others	50 (above 0.5~1μ)	Here copper scrap (in the shape of wool is held in between wire nettings (made from galvanized wire of steel or just steel or brass wire), and oil is applied at the time of using, in order to get the dust adhered. The adhered dust is removed by washing with oil so that it can be used over and over again
Unit type air filter (glasswool,. dry type)	Rooms where ordinary dust collector cannot be used	60~90 (above 1.0μ)	The filter consists of glass fiber held in between metallic wire netting. The filter is thrown away when it becomes dirty and is replaced by a fresh new one.
Unit type air filter (non-woven cloth, dry type)	Used together with ordinary building electrical dust collector	70~90 (above 0.8μ)	The synthetic fiber is made to adhere to each other using synthetic resin. The dirt is washed away using detergent, and the filter is used over and over again.

Auto roll air filter (non-woven cloth)	Mostly used together with ordinary electric dust collector, although used alone occasionally	70～90 (above 0.8μ)	Here the synthetic fiber (nylon or Tetron) is formed in the form of a roll (above 15 cm). The dust collecting face gets wound up when it gets dirty, exposing fresh new face. The filter is replaced by a fresh new one when the roll is wound up completely.
Multipanel air filter (wet type)	Ordinary buildings and others	50～60 (above 1.0μ)	Here, an oil film is formed on the screen panel surface, and the screen panel is guided into the oil tank for removing the adhering dust. Attention is paid to the degree of soiling of the filter oil in the oil tank, and the oil is either cleaned by filtering or replaced by fresh new oil if the oil becomes too dirty.
Grease air filter	Used in the kitchens	50～60 (above 0.5～1μ) Ⓗ	It consists of specially processed copper in the shape of spiral. It captures the oily smoke thereby preventing the possibility of fire in the dust collector. Oil film is not formed on this filter.

halls. (hoods, ducts, water checking dampers and exhaust fan etc.).

The greatest problem is posed by the grease filter fitted inside the hood. Quite often fires have broken out in the kitchen because of improper cleaning of the grease filter or for using the system minus the filter. As much depends upon the conciousness of the people working in the kitchen on the vital role played by the grease filter, they should be properly appraised on its importance. The grease filter should be cleaned periodically so that it arrests the smoke of oil, thus keeping the duct free of it.

2) On installing the exhaust device in the kitchen system

Limitation of space comes as a highly restrictive factor in the case of kitchen. Proper care should be paid to the place of installation of the exhaust system and space required for inspection of the duct.

3) Structure and inspection of the duct

The duct constitutes one of the most difficult part in the system insofar as inspection and cleaning are concerned. Again, in most of the cases the duct is kept hidden inside the ceiling. Thus, it is necessary to provide inspection windows (of sufficiently large size so that the whole duct can be investigated) at proper intervals in the duct. These windows should also facilitate the removal of the oily substance accumulated on the duct floor as this will ensure prevention of fire. Again, sprinklers may be installed inside the duct so that quick steps can be taken to put off fire in case it breaks out inside the duct.

4) On fire preventing dampers

It seems that not much attention is paid normally to the cleaning of the fire preventing dampers in the day to day routine cleaning operations. As the fire preventing dampers should discharge their intended function at the time of outbreak of fire, they should be cleaned properly and regularly, their opening and closing should be checked up, and the fuse should be properly inspected.

The points discussed above hold good for the exhaust systems other than those for the kitchens as well.

7. Maintenance and Management of the Air Filters on Contract Basis

When a building is rented out, the tenant may enter into an agreement with the manufacturer or the contractor specializing in cleaning for the inspection and maintenance of the equipment [air conditioner (package) and exhaust device used in restaurant or employees dining hall]. Again, the tenant may also entrust the job to the management of the building or the company carrying out the management.. The scope covered while accepting the maintenance from the tenant on contract basis has been shown in Table 2.

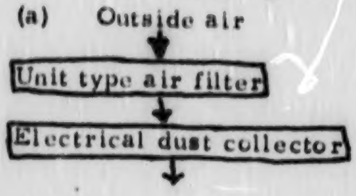
8. Management of the Air Filter in the Office Building

1) Using a combination of the air filters

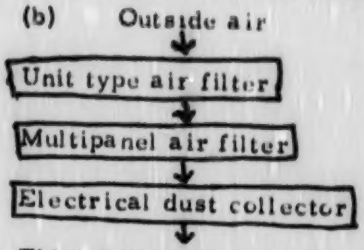
As has been stated earlier, it is necessary to select the air filter for air conditioning, especially the air filter used at the inlet of the outside air, carefully after proper study. Again, the use of a combination of two or three air filters rather than a single individual filter should also be investigated. In short, such a step will result in raising the dust collection efficiency of the conventional multipanel air filter by using other type of air filter together. Thus, it becomes necessary to have a reappraisal of the efficiency of the different types of air filters.

The following combinations can, however, be recommended

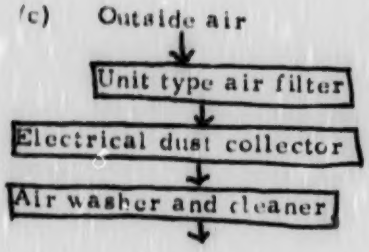
(a)


Outside air
Unit type air filter
Electrical dust collector

(b)


Outside air
Unit type air filter
Multipanel air filter
Electrical dust collector

(c)


Outside air
Unit type air filter
Electrical dust collector
Air washer and cleaner

This particular process ensures the removal of gases like sulfur dioxide by washing, but steps should be taken here to check the corrosion of the water drainage pipe due to the sulfuric acid that gets dissolved in water.

TABLE 2

Scope of management accepted on contract

Place of installation	Name of equipment	Items covered in maintenance	Cleaning frequency
Office	Air conditioner (package)	1. Inspection of pressure switch, water cut off relay, electromagnetic valve, thermostarter. 2. Washing and cleaning of the air filter	1~ 2 times per month
Shops (restaurants)	Kitchen exhaust device (hoods, grease air filter, and fire preventing dampers are included)	1. Removal of the oily substance adhering to the inner side of the hood and its proper cleaning. Cleaning of the grease filter (washing with cleaning oil).	4 times per month.
		2. Inspection (measurement of volume of air and static pressure), cleaning and oiling of the exhaust fan.	1 ~2 times per month.
		3. Cleaning of the exhaust fan (removal of oily substance adhering to the fan blade).	Once per month.
		4. Cleaning of the fire preventing dampers and check up of their working and the fuse.	Once per month.

2) Selection of the air filter

With the tremendous progress in research and development in technology, a large vareity of filters have been produced and marketed. It is necessary to carry out a thorough study of these newly developed filters and select the filter best suited to the conditions of the building (this is needed at the time of initial installation). Next comes the question of management, which includes not only the inspection and cleaning of the air filter, but also a check up of the cleaning efficiency as well as prevention of intrusion by harmful substances. (See pp. 98-101).

9. Conclusion

A discussion has been carried out above on the maintenance and management of the air cleaning devices used in the office buildings. It is necessary to give a careful thought on the selection of the air cleaning device at the time of designing the building, and after installing the appropriate air filter its maintenance and management should be carried out properly by qualified technicians. Only after adopting these steps it will be possible to ensure the circulation of clean air inside the building.

Check-up of the air filter
(Note: Points to be checked have been given inside parenthesis)

Name of the device	Points to be checked	Frequency			
		Day	Week	Month	Year
1	2	3	4	5	6
Electrical dust collector	1. Inspection of the dust collection unit (Inspection of the dirt in the dust collection unit, degree of soiling of the dust collection unit)		○		
	2. Inspection of the back filter (Washing back filter with hot water and cleaning)		○		
	3. Inspection of the power source (Inspection of the DC high voltage generator, and the power source protector at the time of short circuit of the high voltage circuit)			○	
	4. Dismantling the dust collection unit and washing of the electrode plates (Dismantling the dust collection unit and washing with water or hot water, cleaning, thorough drying and finally applying the adhering agent)		○		
	5. Inspection of the washing tube and the travelling washing mechanism (washing pump, electromagnetic valve, adhering agent pump and control panel) (Inspection of the travelling washing mechanism and the parts of the constituents, cleaning of the knob of the washed water exhaust opening and the joints, washing water supply pipe and resetting so that the cleaning operation goes on smoothly)			②	
	6. Minute inspection of the whole dust collector (Inspection of the whole dust collector is carried out minutely for detecting any abnormality, which if detected set right)				②
	7. Cleaning of the dust collection unit of the outside air harmonizer (in shops and stores) (The washing of the dust collector should be thorough in the case of shops and stores as the degree of soiling is relatively higher here)	○			
	8. Washing of the dust collection unit of the air conditioner in the shops and stores (The procedure laid down in 7 above applies here)	○			

Multipanel type air filter	1. Inspection of the degree of soiling of the screen panel (filter wire netting) (Inspection of the soiling of the panel is carried out and steam washing is carried out Outside air harmonizer: once in 3∼6 months Outside air harmonizer (shops and stores): once every day Air conditioners (tenant offices): once in every two years)			●
	2. Inspection of the interior of the oil tank (The degree of soiling of the filter oil in the oil tank and the state of precipitation or adhesion of the injurious substances at the bottom or at the side of the oil tank are inspected)	○		
	3. Inspection of the rotating transmission device (Inspection of the state of rotating transmission device, reduction gear and lubrication, and study of the state of the wire netting section once a year)		○	
	4. Inspection of the degree of blowing off of the filter oil from the screen panel (If the degree of blowing off of the oil from the panel becomes too serious, then the panel should be cleaned with steam, and the interior of the casing in front of and behind the multipanel should be cleaned)	○		
	5. Filtering the filter oil inside the oil tank and supplementing the shortfall (Proper attention should be paid to the degree of soiling of the filter oil in the oil tank, and it should be cleaned by filtering with activated clay or with a filter. Fresh oil should be added from time to time to supplement the shortfall)			●
	6. Detailed inspection of the multipanel (Parts which cannot be covered during the routine inspection like the rotating parts, the panel section and the oil tank etc. should be inspected and the necessary repairs and adjustments should be carried out after dismantling).			●

Contd.

1	2	3	4	5	6
	8. Inspection of the filter casing (Inspection for corrosion etc. of the casing is carried out and the necessary repairs are undertaken)		o		
Automatic winding type air filter (non-woven cloth)	1. Greasing of the winding shaft and the bearing (The winding shaft is inspected, and the grease of the bearing is changed)				②
	2. Inspection of the switch of the micromanometer (Working of the switch is inspected and the necessary repair or adjustment is carried out)	o			
	3. Inspection of the endless chain and gear (The chain and the gear are inspected and the necessary lubrication and adjustment are done)			④	
	4. Inspection of the upper and the lower guide rolls (Inspection of the guide rolls is carried out and the necessary adjustment or repair is carried out)			o	
	5. Inspection of the pressure difference detection tube (The degree of soiling of the detection tube is inspected, and the pressure working at the entrance and exit of the filter is checked)	o			
	6. Inspection of the control panel (Working of the micromanometer, power lamp, pressure difference working indication lamp, filter changing lamp, manual motor switch and automatic switch is checked)	o			
	7. Driving device and automatic winding device (Detailed inspection of the automatic stopping switch, winding speed reduction motor, drive and automatic mechanisms is carried out)			o	
	8. Detailed inspection covering the whole air filter device (This detailed inspection should also include the parts which cannot be covered in the routine inspection)				②

	9. Washing and changing the filter (non-woven cloth) (Washing and changing of the filter should be entrusted to the parties specializing in the field)			□
	The check-up of the unit type air filter is given below			
Unit-type air filter (non-woven)	1. Inspection of the degree of soiling of the air filter and its washing (The filters with high degree of soiling should be taken out, washed with detergent, dried thoroughly and used again. However, 1/3rd of the total number of filters used should be kept in reserve)		②	
Unit-type air filter (metalwool)	1. Inspection of the degree of soiling of the air filter and its washing (The filter is taken out of the frame and washed with oil. The washing frequency is increased depending upon the place where the filter is installed)	○		

Note: The check-up points given above have been reproduced from the checklist for 'Equipment and Management' (by Kasahara) appearing in the January 1969 issue after some modification with the permission of Ohm Co. In the table, ○ means once, ② means twice, ④ means four times and □ means once a year entrusted to the parties specializing in the field.

MAINTENANCE AND MANAGEMENT OF THE AIR CLEANING DEVICES IN THE FACTORIES

S. ITO

I. Introduction

Besides bringing about revolutionary changes in the production process and acceleration in the degree of rationalization and mechanization, the recent technological innovations are creating an everincreasing demand for new raw materials which more often prove to be occupational hazard causing new occupational diseases unknown till now, thereby turning the place of work into some sort of a 'place of health hazard' for the workers.

The Ministry of Labor has drawn up the Third Basic Plan for Preventing Industrial Accidents in 1968, with the object of 'reducing the lead poisoning, chemical solvent poisoning and dust induced chest diseases' and eliminating the poisoning due to nitroglycol and 11 other harmful chemicals'. According to the provision of the plan, annual projects are drawn up for implementing the necessary countermeasures. A new object, viz., 'decreasing absenteeism due to illness', has been added to the above plan only last year, as absenteeism due to illness has become a major headache for the industry, accounting for ten times more losses in the man days compared to that for the accidents.

The industry is at present passing through a phase of unprecedented labor shortage, and this problem is going to aggravate further in the future. Simultaneously, both the labor and the management have also become extremely concious about hazardous environment at the place of work and the occupational hazards and diseases. Time has come for the Ministry of Labor to join hands with the labor and management for creating 'pleasant working environment' rather than 'harmless working environment'.

Under such a situation, considering from the angle of labor hygiene, it becomes necessary to detect the causes of generation of the harmful substances and device steps to eliminate them.

II. Legal Measures for Preserving the Environment

There are a number of laws and regulations concerning labor hygiene like Labor Standard Law, Dust Induced Lung Diseases Law, and the laws related to the industrial accident prevention associations, and the regulations and ordinances issued on the basis of the above laws.

The regulations and ordinances concerning labor hygiene specify the detailed steps to be adopted, determined after taking the methods and techniques of production, and the raw materials used into consideration. As all the laws, regulations and ordinances cannot be said to be very comprehensive, proper modifications and additions should be carried out in future.

In response to the regulations and ordinances, a number of local disposal devices have been developed based on chemical principle for eliminating the injurious gases, vapors and dusts.

The Organic Solvent Poisoning Prevention Regulation stipulates the compulsory installation of air exchange device for changing the air locally in the factories where operations involving 49 chemical solvents like benzene, toluene, gasoline etc. are involved. Again, concrete specifications have been laid down on the level of performance to be maintained by the devices, and procedure has also been laid down for their maintenance.

The Lead Poisoning Prevention Regulation also stipulates steps on the line mentioned above for preventing harms caused by lead and its compounds.

The Dust Induced Lung Diseases Law deals mainly with health control for preventing the lung diseases caused by the inhaling of the dust. The operations involving dust have been covered in the Appendix I of the Ordinance for Enforcing the law. Of these, the Industrial Safety and Hygiene Law, Act

No. 173, provides for installation of local air exhaust device for the following indoor cases in its following clauses.

1) Clause No. 4

(i) Polishing carried out with power using polishing agent (excluding the operations involving hand grinder, swing grinder (hanging grinder) etc. where providing local air exhaust device proves to be technically very difficult).

(ii) Operations where grinding is carried out by blowing in the abrasive. (Excluding operations like internal grinding of large sized tanks, de-rusting the blocks of ships etc. where providing local air exhaust device proves to be extremely difficult).

2) Clause No. 8

(i) Crushing operation carried out with the help of the following pressure crushing type crushers: a) Jaw crusher, and b) Roll crusher.

(ii) Crushing operation carried out with impact type crushers like swing hammer, crusher, impeller flaker etc.

(iii) Crushing operation carried out with roller mills like edge runner mill, ring roll mill etc. (excluding the wet operations).

(iv) Crushing operation carried out with the help of the ball mills and rod mills etc. (excluding the wet type).

3) Clause No. 9

The following operations in the process of manufacturing glass and enamel. (i) Sieving the raw materials: (ii) Mixing the raw materials.

4) Clause No. 10

The following operations involved in the manufacture of the ceramics. (i) Sieving the raw materials. (ii) Mixing the raw .

materials. (iii) Giving finishing touch to the finished or semi-finished products.

5) Clause No. 11

The following operations involved in the manufacture of refractories, Kieselguhr wares and abrasives.

(i) Sieving the raw materials. (ii) Mixing the raw materials (iii) Giving finishing touch to the finished or semifinished products.

6) Clause No. 13

Operation of sieving the raw materials involved in the manufacture of powdered talc and clay.

7) Clause No. 14

The following operations involved in the manufacture or processing by using talc or clay as a raw material.

(i) Mixing of powdered talc or clay or substances containing these.

(ii) Dispersing powdered talc or clay or substances containing these.

8) Clause No. 15

The following operations involved in the manufacture of the carbon products. (i) Sieving the raw materials. (ii) Mixing the raw materials (iii) Giving finishing touch to the finished or semifinished products.

9) Clause No. 16

The following operations involved in the manufacture of cement.

(i) Sieving the raw materials or the roasted granules.

(ii) Packing the finished cement in bags.

10) Clause No. 17

The operation of packing in bags of the products in the manufacture of aluminum powder.

11) Clause No. 18

The following operations involved in the manufacture of castings using sand moulds.

(i) Sieving the sand.

(ii) Breaking up the mould or removing the sand with the help of mould breaking machines like shake out machine or knock out machine.

12) Clause No. 20

Sieving the roasted granules in the refining of the metals and nonmetals.

13) Clause No. 21

Welding of the metals.

14) Clause No. 22

The operation of packing of the products of clay, or fly ash or powdered Kieselguhr, talc or carbon.

15) Clause No. 23

(i) The following operations carried out with the machines handling asbestos.

a. Untangling operation. b. Bonding operation.
c. Spraying operation. d. Spinning and weaving operation.
e. Carding operation.

(ii) The following operations carried out with the machines handling the asbestos products.

a. Cutting operation. b. Grinding operation.

Engineering measures involving the use of local type air exhaust device are adopted at present for eliminating the dust produced during the above operations, and the necessary technical guidance is provided by the dust countermeasure guidance experts (these are the scholars in the fields of science and engineering employed in the universities and appointed by the Minister of Labor. They are assigned to the Labor Standard Bureaus of the prefectures and local bodies) and the regional labor hygiene experts in government service. Tables 1 and 2 show the results of guidance provided with regard to the various dust-operations in different industries during the year 1968 for reference. The improvements effected as a result of guidance have been shown inside parenthesis.

It is obligatory to instal local air exhaust device, as mentioned above, for maintaining a healthy working environment. The Act No. 54 of the Labor Standard Law lays down that the plans of installation of the air cleaning devices should be submitted to the office of the Labor Standard Superintendent 14 days before starting the actual construction. After scrutiny of the papers if it is found that the steps proposed are inadequate for guaranteeing the safety and health of the workers, then the construction work should be postponed and a revised plan should be submitted. The form related to the local exhaust of air which should accompany the plan has been shown in Table 3. (The subsequent maintenance and management becomes very easy if a copy of this form is preserved along with the Inspection Record Chart for the local air exhaust device).

III. Maintenance and Management of the Local Air Exhaust Device

Maintenance and management of the local exhaust device involve primarily a proper understanding of the state of operation and performance of the device, besides knowing whether it

TABLE 1
Results of guidance-provided in the various industries (for 1968), National Labor Standard Bureau

Details / Industries	Number of enterprises where individual guidance was provided	Number of days the individual guidance was provided				Details of the individual guidance (and the improvements achieved) (Number of cases)						
						Engineering steps						
		Total	Dust counter measure guidance report	Labor hygiene expert	Others	Local air exhaust	Total air exhaust	Mechanization	Sealing (cover)	Wet type (supplying moisture)	Isolation	Other steps
Metallic furniture and accessories manufacturing industry	8	22	8	9	5	6(4)	2(1)	2(1)			1(1)	4(3)
Furniture and accessories manufacturing industry	55	165	25	35	45	78(30)	11(8)	2(1)	2	3(2)	5(4)	15(7)
Pulp, paper and paper products manufacturing industry	37	75	17	18	40	31(17)	11(6)		5(1)		3(1)	4(4)
Printing and book production industry	35	73	26	23	24	46(33)	12(7)	2(1)	1(1)		3(3)	13(4)
Rubber products manufacturing industry	65	110	25	16	69	80(54)	28(13)		1(1)	2(1)		8(6)
Chemical industry	198	450	116	107	227	221(130)	58(30)	14(9)	47(29)	3(3)	9(5)	39(30)
Cement industry	17	31	1	4	26	15(13)	7(6)	1	11(4)	5(4)	3(3)	1(4)
Glass industry	34	71	18	16	37	29(13)		2(2)	6(4)	2(2)	2(1)	11(4)
Ceramic industry	133	236	61	59	116	251(141)	11(5)	6(3)	41(19)	17(7)	8(8)	5
Refractory brick industry	61	118	19	25	74	80(53)	6(1)	3(3)	66(50)	1(1)	9(6)	21(13)
Other pottery industry	194	271	65	58	148	112(70)	14(10)	7(5)	34(19)	8(5)	9(2)	28(20)
Other earthen and stoneware manufacturing industry	209	298	48	43	207	[illegible]	13(9)	15(9)	59(41)	18(9)	10(6)	40(26)
Iron and steel and rolling industries	65	120	29	24	67	50(43)	19(15)	4(3)	12(10)	5(5)	2(2)	21(16)
Casting industry	485	728	152	101	475	[illegible] (272)	88(67)	43(25)	50(37)	28(18)	19(9)	111(90)
Other iron and steel industry	21	33	3		30	4(3)	4(1)		1			4(2)
Non-ferrous metal refining and rolling industry	13	39	5	6	28	25(19)	6		5(4)	2(2)		5(4)
Non-ferrous casting industry	52	74	21	19	34	41(30)	14(5)	1(1)	1(1)	3(3)		9(8)
Other non-ferrous metal industry	16	36	15	10	11	20(19)	4(2)					7(4)
Metal product industry	319	523	139	113	271	233(126)	39(33)	12(5)	13(7)	2(2)	7(4)	77(61)
General machinery and tools industry	313	438	96	81	261	219(147)	58(30)	17(10)	13(8)	6(5)	16(7)	28(21)

Electrical machinery and instruments industry	91	184	53	55	76	116(89)	32(23)	15(13)	14(10)	3(3)	3(2)	19(11)
Shipping industry	72	115	23	21	71	50(32)	10(5)	5(4)	2(2)	1(1)	1	12(12)
Other transportation machinery manufacture industry	56	116	35	40	41	59(45)	25(20)	23(18)	1(1)	2(2)	5(4)	2(2)
Manufacturing industries not falling under the categories mentioned above	93	181	64	59	58	79(60)	32(14)	8(6)	14(10)	5(2)	7(3)	17(7)
Ordinary coal mining												
Non-coal mining												
Sand mining												
Other metal mining	39	57	6	6	45	3(2)	4(3)	2(1)		8(5)		4(4)
Petroleum tapping												
Stone quarring	485	365	4	6	355	4(2)	5(4)	3(1)	4(2)	46(36)		31(27)
Other stone and clay quarring	25	26		2	24	2(1)	1		1	1(1)		5(3)
Other non-metallic mining	13	23		1	22	6(3)	2(1)		3(2)	4(2)	3(3)	6(4)
Constructions related to hydroelectric power generation	8	11	1	3	7		2(2)	2(2)	2	3(1)		
Tunnel construction	133	179	6	27	146	9(2)	16(10)	2(2)		20(17)	1(1)	23(23)
Bridge and related constructions	1	3	1	1	1			1(1)			1(1)	
Constructions not covered by those mentioned above	46	84	20	13	51	1(1)	2(1)	1(1)	4(3)	19(12)	2(2)	24(17)
Enterprises not covered by the above	41	76	28	17	31	21(7)	136(63)	3(1)	7(5)		4(1)	20(13)
Total	3,435	5,271	1,130	1,018	3,123	2,433 (1,548)	656(369)	196(128)	436(271)	206(107)	139(79)	617(400)

TABLE 2

Dust-producing-industry-wise break-up of the results of guidance (for 1968), National Labor Standard Bureau

Classification of the industries where guidance was provided (Appendix I of the Ordinance for enforcing the Dust Induced Lung Disease Act)		Type of guidance provided (and improvements achieved) (number of cases)						
		Local air exhaust	Total air exhaust	Mechanization	Sealing (cover)	Wet method (supplying moisture)	Isolation	Other steps
1		2	3	4	5	6	7	8
1 Digging up stones and earth		7(4)	6(6)	5(3)		69(50)	1(1)	65(51)
2 Overturning wagons containing stones and earth		2(1)	( )	2(2)		9(3)		3(3)
3 Coal	(1) Cutting					7(5)		1
	(2) Chiseling			1		3		1
	(3) Pickax work	2						1
	(4) Striking	3(1)				1		1
	(5) Power polishing	1						3(3)
4 Abrasive agent	(1) Power polishing	497(364)	49(27)	4(4)	13(5)	7(7)	11(9)	75(58)
	(2) Spray polishing	64(58)	8(8)	7(7)	9(7)	1(1)	5(5)	8(7)
5. Inside the mine	(1) Crushing and powdering of the earth and stone	4(1)	10(8)			16(16		2(2)
	(2) Sieving the crushed earth and stone							
	(3) Packing etc. of the crushed earth and stone		4(3)			2(2)		
6 Transportation of stones and earth inside the mine		2	3(3)	1(1)		1(1)		5(5)
7 Inside the mine	(1) Filling with earth and stone	2						
	(2) Spreading crushed rock							5(5)
8 Crushing stone and earth indoors		135(82)	23(9)	11(6)	77(45)	11(8)	10(8)	35(30)
9 Glass	(1) Sieving the raw materials	6(3)			1(1)			7(3)
	(2) Mixing the raw materials	11(6)	1(1)	1(1)	5(3)	1(1)	1(1)	3(2)

		(3) Carrying the raw materials to the kiln	7(3)		1 (1)	1(1)			1(1)
10	Ceramic wares	(1) Crushing and powdering the raw materials	78(61)	3(1)	2(1)	37(20)	15(5)	3(3)	1
		(2) Sieving the raw materials	42(31)	4(3)		11(7)		4(4)	2
		(3) Mixing the raw materials	43(30)		5(4)	8(6)			1
		(4) Drying the raw materials	5(1)	1(1)		1(1)			
		(5) Moulding	43(27)	2			1(1)		1
		(6) Finishing	34(23)	2					1
		(7) Putting inside the kiln and bringing out from it it	4(1)		1		2(2)	1(1)	1
11	Refractory materials	(1) Crushing and powdering the raw materials	63(40)	6(4)	2(1)	49(38)	7(5)	12(7)	9(4)
		(2) Sieving the raw Materials	12(8)	7(5)	4(1)	20(15)		3(2)	3(2)
		(3) Mixing the raw materials	24(11)	3(3)		9(5)		1	10(5)
		(4) Drying the raw materials	6(4)	2(1)	2(1)	2(2)		1(1)	1(1)
		(5) Moulding	35(26)	1					2(2)
		(6) Finishing	12(11)	4(2)					1(1)
		(7) Putting inside the kiln and bringing out			8(8)			1(1)	2(2)
		(8) Packing the product	10(5)	5(4)	2(1)	2(2)			
12	Kiln	(1) Making the kiln and repairing	6(3)	2					
		(2) Dismantling the kiln							
13	Talc	(1) Crushing	6(3)	3(1)		4(1)		2	2
		(2) Sieving	2			4			
		(3) Drying				3			
14	Talc	(1) Mixing	68(47)	15(12)	9(3)	3(3)		4(2)	5(5)
		(2) Scattering	21(11)	6(2)	1		2(1)		2(2)

Contd.

		1	2	3	4	5	6	7	8
15	Carbon	(1) Crushing and powdering the raw material	4(3)	2(1)		5(5)		2(2)	3(2)
		(2) Sieving the raw material after crushing	11(5)	2			2(1)		1
		(3) Mixing the crushed raw material	3(3)	1	1(1)	2(1)		2	3(1)
		(4) Drying	3(1)	1	1(1)	2(1)			1
		(5) Moulding	4(2)	2(1)					5(3)
		(6) Finishing	4(1)	2	1(1)	1(1)			1(1)
16	Cement	(1) Crushing and powdering the raw materials	5(5)	2(2)	1	3(3)	4(4)		1(1)
		(2) Sieving the raw materials	4(4)	3(3)		8(2)	1	1(1)	
		(3) Packing the finished product in the bags	6(5)	3(2)	1(1)			1(1)	2(3)
		(4) Loading and unlodding	1(1)						3(3)
17	Aluminium powder	(1) Crushing	7(6)			3(3)			
		(2) Packing in bags	1(1)						1(1)
18	Sand mould casting	(1) Sieving the sand	143(90)	27(13)	44(29)	39(22)	6(3)	21(7)	36(26)
		(2) Pouring	35(19)	31(13)	4(3)	2(1)	3(3)	2	28(25)
		(3) Breaking up the mould	94(48)	60(42)	18(6)	2(2)	16(13)	1	23(21)
		(4) Shaking out the sand from the mould	113(61)	34(20)	38(27)	12(7)	11(10)	1(1)	31(19)
		(5) Chipping	54(14)	8(6)		1(1)		4(1)	13(13)
19	Roasting of powdered ores	(1) Churning the roasted ore for the ash to drop off	3(2)						
		(2) Loading and unloading the ash	6(3)	1(1)	1	1			2(1)
20	Refining the metals	(1) Feeding into open furnace made of stone & earth	39(27)	5(2)		2			5(3)
		(2) Sintering	10(7)	2(2)	2(1)	1(1)			3(1)
		(3) Sieving the sintered product	5(4)	3(3)		1(1)	1(1)		

		(4) Tapping	11(6)	4(2)					
		(5) Pouring	14(7)	16(5)				3(3)	3(3)
		(6) Removing the slag from the furnace	7(4)	1(1)	1	1			
		(7) Loading and unloading the slag	1(1)	3(2)	1 (1)	1(1)	1(1)		2(1)
		(8) Packing of the slag	2(2)	1					
21	Spraying and welding	(1) Spraying	11(2)		1 (1)		1(1)	1	
		(2) Welding	66(35)	24(10)	3(3)	2(2)	1(1)	9(5)	43(38)
		(1) Packing the product in the bag	26(10)	9(5)	2(1)	6(2)	1(1)		3(3)
22	Clay etc.	(2) Loading and unloading the product	7(3)	3(2)				1(1)	2(2)
		(3) Packing the product	3(1)	1(1)					1
		(1) Untangling	6(5)	1(1)		1			
		(2) Bonding	5(4)	3(1)					
		(3) Blowing							
23	Asbestos	(4) Carding	7(4)						
		(5) Loading and unloading	1(1)						
		(6) Putting in layers							
		(7) Cutting and grinding	13(6)	2(1)		1			2(1)
24	Others		441(280)	229(123)	11(7)	70(55)	6(6)	17(12)	139(77)
		Total	2,433(1,540)	656(369)	196(128)	426(271)	209(147)	133(79)	617(440)

TABLE 3

Design Specification Form for local air exhaust device

Name of the company		Address	
Position of the intended operation (process) inside the structure	Shown in attached diagram		
Intended operation (process)	①	②	③
Details of the intended operation (process) (details of the operation like the raw materials to be utilized, machinery, tools and instruments to be used and the process to be employed should be mentioned in concrete terms)	①	②	③
Position of the hands and the operators (to be shown with the help of diagrams)	①	②	③

Hood	Model			① Type	② Type	③ Type
				Model	Model	Model
	Opening	Shape		As shown in the figure in ① on the right	As shown in the figure in ② on the right	As shown in the figure in ③ on the right
		Size	Circular	Diameter	Diameter mφ	Diameter mφ
			Rectangular	Longer side m Shorter side m	Longer side m Shorter side m	Longer side m Shorter side m
			Others	m m	m m	m m
		Area		m^2	m^2	m^2
	Material	Type				
		Thickness (Denier)		m (g)	m (g)	m (g)
	Direction of exhaust			Upward, downward, sidewise	Upward, downward sideward	Upward, downward, sidewise
	Control air speed			m/s	m/s	m/s
	Position from where control air speed is regulated			As shown in the figure in ① on the right	As shown in the figure in ② on the right	As shown in the figure in ③ on the right
	Volume of exhaust air			m^3/min	m^3/min	m^3/min

The ground plan and the elevation of each hood should be given here together with the dimensions of each section

①

②

③

Duct	Shape	Circular, rectangular		Material		Type		
		①Branch duct	Branch duct	Main duct (in between the branch duct ② and duct ①)	Duct	Main duct (in between the branch duct ③ and the air cleaning device)	Exhaust duct (in between the air cleaning device and the fan)	Exhaust duct (in between the fan and the exhaust opening)
	Cross section – Size – Circular	cmφ	cmφ	cmφ	cmφ	cmφ	cmφ	cmφ
	Cross section – Size – Rectangular	cm × cm	cm × cm	cm × cm	cm × cm	cm × cm	cm × cm	cm × cm
	Cross section – Area	m²	m²	m²	m²	m²	m²	m²
	Speed of air	m/s	m/s	m/s	m/s	m/s	m/s	m/s
	Thickness (count)	mm (#)	mm (#)	mm (#)	mm (#)	mm (#)	mm (#)	mm (#)
	Shape of the hoods, enlarged ducts, contracted ducts, and the exhaust opening (the shapes are illustrated with diagrams along with the dimension settings)							

Pressure loss (mmH_2O) (total pressure)

	①Branch duct	②Branch duct	Principal duct (in between the branch ducts ① and ②)	③Branch duct	Principal duct (in between the branch duct ③ and the air cleaning device)	Air cleaning device	Principal duct (in between the fan and the air cleaning device)	Exhaust duct (in between the exhaust opening and the fan)	Exhaust opening
Hood									
Straight duct									
Bend									
Confluence duct									
Enlarged duct									
Contracted duct									
Exhaust opening									
Total	A	B	C	D	E	F	G	H	I
Designed pressure loss	● mmH_2O (Decided after comparing A and B)		● mmH_2O (Determined after comparing the values of ● + C and D)		● = ● + E mmH_2O	● = ● + F + G mmH_2O		● = H + I mmH_2O	
Total	● + ● mmH_2O								

Exhaust fan	Selection of the fan	Total pressure of the fan (P_{TF})	mmH_2O	Dynamic pressure of the fan (kW)	$(kW) = \frac{Q \times P_{TF}}{6120 \times \eta_T} = \frac{Q \times P_{SF}}{6120 \times \eta_S}$ kW	Q = volume of air exhausted (m^3/min); P_{TF} = total pressure of the fan (mmH_2O); η_T = total pressure efficiency of the fan; P_{SF} = static pressure of the fan η_S = static pressure efficiency of the fan; P_{V0} = speed pressure at the back of the fan $P_{TF} = P_{SF} + P_{V0}$ $P_{SF} = P_{TF} - P_{V0}$
		Static pressure of the fan (P_{SF})	mmH_2O	(kW)		

Exhaust fan	Type and capacity of the fan installed	Model	Radial Sirocco Turbo Limit load Air foil Axial guide vane	Volume of air	m^3/min	Air pressure	Total pressure	mmH_2O	Rotation	rpm
							Static pressure	mmH_2O	Shaft power	kW
Motor	Motor provided to the fan	Model		Output	kW	Phase	V	~	Rotation	
Detailed diagram	(Diagram given in the attached sheet)									

Air cleaning device	Dust removing device	Filter type (pack filter)	Filter	Material		Mechanism of removing the dust	Present (automatic/manual)/absent
				Shape and dimensions	Shown in the attached diagram	Dust collection capacity (dust box)	Shown with the help of the attached diagram
				Others		Method of taking out the dust	Screw conveyor etc., scoops, others ( )
		Centrifugal type (cyclone)		Material		Dust collection capacity (dust box)	Shown in the attached diagram, m³
				Shape and dimensions	(Shown in the attached diagram)	Method of taking out the dust	Screw conveyor etc., scoops, others ( )
		Others					
	Others						

Distribution of the local air exhaust devices (shown in the attached diagram)	

Note: 1) In case of the presence of four or more branch ducts, these should be mentioned with proper modification

2) Separate sheet of paper should be used in case the space provided for noting proved inadequate

is working as per the design specification. If any defect is detected anywhere, it should be rectified immediately in order to ensure the working of the device at the rated performance level (performance of all the section like the hoods, ducts, air cleaning device and fans etc. is involved). Even though the performance of such devices is expressed simply by that of the air cleaning device, yet the performance on the whole cannot be considered to be satisfactory if the suction by the hood happens to be bad or the resistance inside the duct increases due to the accumulation of dust etc.

Consequently, the common problems faced during the maintenance and management of the local air exhaust device and the air cleaning device will be discussed here, touching upon the causes that give rise to the problems and the steps that should be adopted.

1) Preparations and Inspection of the Local Air Exhaust Device

(i) Sketch of the local air exhaust device in brief

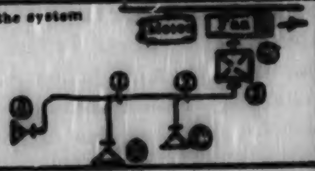
The brief sketch of the local air exhaust device should be a simple one giving the distribution of the hoods, main duct and the branch ducts, as well as the location of the air cleaning device, the fan and the motor. The dimensions of the ducts and the capacity and the model of the air cleaning device, the fan and the motor should be recorded in the brief diagram, and the places where the measurements should be carried out should be indicated with the help of symbols and sequence numbers.

(ii) Inspection Record Form

The Inspection Record Form should preferably embody the brief sketch. The inspection record form can be prepared arbitrarily by the person carrying out the inspection as he finds convenient. However, one such forms has been shown in Table 4 for convenience.

TABLE 4

Inspection Record Form

Date of inspection	Date	Name of the person carrying out inspection	
Number of the air exhaust system: No. Air contaminant treated Factors to which the system is applicable (1) (2) (3) (4)	Brief sketch of the system 		

1. Hood

Hole for testing	State of the hood and the duct (convenience, damages, closed wall, requirement of repairs etc.	Pull by the hood			
		At the time of inspection		At the time of installation	
		P_s mmH$_2$O	Q(m^3/min)	P_s(mmH$_2$O)	Q(m^3/min)
①					
②					
③					

2. Duct

Hole for testing	Duct diameter (cm)	Static pressure (mmH$_2$O)	Speed pressure (mmH$_2$O)	Speed of air (m/s)	Volume of air (m^3/min)
①					
②					
③					
④					

3. Air cleaning device

Model		Amount of contaminant recovered	kg
Volume of water consumed		Cleaning efficiency (efficiency of dust removal)	%
Pressure loss	⑤-⑥ mmH$_2$O		
Duration of operation	hr		

4. Fan and motor

	Model	(No.) (Plate kW)	Rotation (r.p.m.)	Voltage (E) (E)	Current (I)	EIφ or $\sqrt{3}EI\phi$	Fan efficiency η_T or η_s
Fan							
Motor							
Place of measurement	Duct radius cm	Static pressure mmH$_2$O	Speed pressure mmH$_2$O	Total pressure mmH$_2$O	Volume of air Q m^3/min	Fan total pressure mmH$_2$O	Fan static pressure mmH$_2$O
Fan pull side							
Fan push side							

5.	Points of attention and remarks

(iii) Measurement Hole

The holes for measuring the static pressure at the various sections of the local air exhaust device should be located at the hood (at the juncture of the hood and the duct, at the strategic spots in the duct, in the air cleaning device and before and after the fan. Again, holes should be provided before and after the air cleaning device and uniform speed suction should be carried out for determining its efficiency. The size of the measuring holes should be sufficient to accommodate the sensing parts of the measuring instruments. Again, the sensing parts should remain at right angles to the duct wall. Furthermore, hangnails should not be present on the inner wall of the duct.

When not in use these measurement holes should be plugged with rubber stoppers.

2) Defective Spots in the Various Sections of the Local Air Exhaust Device

(i) Hood

The 'Smoke Method' is most simple and convenient for determining the state of pull air current in the hood, although it is better to use a hot wire anemometer for knowing the control air speed quantitatively. Usually, the pull air current is different from the push air current, inasmuch as its speed falls rapidly with the increase in the distance from the pull opening, and it loses its effect almost completely if the distance increases beyond 1 m. For example, as shown in Fig. 1, in the case of pull, the speed of pull air current at a distance equal to the diameter of the pull opening away from the duct falls to about 1/10th of that at the pull duct opening; whereas in the case of push, the speed of push air current drops to about 1/10th of that at the push duct opening at a distance equal to about 30 times the diameter of the push opening away from the duct. Thus, the decrease in pull air speed is much greater compared to that in the push air speed. When the local air exhaust device is considered in this light, it becomes indispensible to position the hood opening very close to the emission source of the dust or the gas etc., in order to obtain the expected result. Consequently, it is necessary to have a proper understanding of the state of the pull opening and the pull air current when assuring the control air speed.

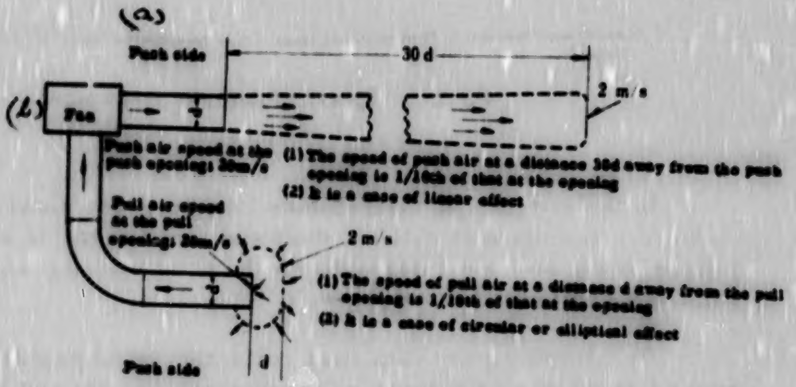

(a)
Push side
30 d
2 m/s
(b)
Fan
Push air speed at the push opening: 20m/s
(1) The speed of push air at a distance 30d away from the push opening is 1/10th of that at the opening
(2) It is a case of linear effect
Pull air speed at the pull opening: 20m/s
2 m/s
(1) The speed of pull air at a distance d away from the pull opening is 1/10th of that at the opening
(2) It is a case of circular or elliptical effect
Push side
d

Fig. 1. *Characteristic features of push and pull.*

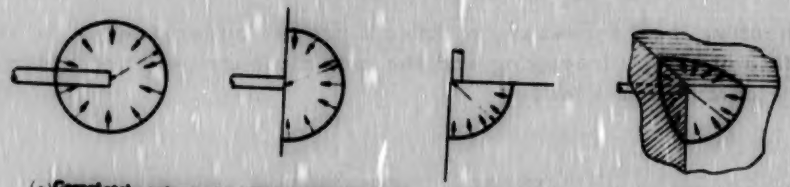
While making a fundamental study of the case, if the pull source (hood opening) is assumed to be a point, then the uniform speed plane of the air current flowing towards the pull opening can be treated as spherical in shape with the pull opening as the center.

a) Completely spherical plane: When the duct opening is located in free space.

b) Hemispherical plane: When the opening is provided with a flange or when the opening is located by the side of a wall.

c) 1/4th spherical plane: When the opening is close to the juncture of two planes intersecting at right angles (for example, two walls).

d) 1/8th spherical plane: When the opening is located near a corner where three planes intersect at right angles (for example two walls and the ceiling).



(a) Completely spherical plane (b) Hemispherical plane (c) 1/4th spherical plane (d) 1/8th spherical plane

Fig. 2. Spherical uniform speed plane.

In the absence of instruments like hot wire measurement coil etc., the state of pull for dust and smoke etc. is sometimes judged by focussing strong light on the hood opening and observing the movements taking place.

By compiling the data thus collected, a judgement is passed on whether the hood is appropriate or not; and in case the hood is adjudged to be defective, then the cause is ascertained.

The following can be considered to be the causes for the defective hood.

A. Causes of defect

1. The amount of air exhausted by the fan is insufficient.

2. The distance from the source of generation to the hood opening is large.

3. The pressure loss increases due to accumulation of dust etc. in the duct system, and because of this the rated volume of air exhausted is not achieved.

4. The air current near the hood opening and the source of origin cannot be controlled effectively under the influence of outside air.

5. The diffusion speed of the harmful substance being large, it disperses outside the sphere of influence of the hood.

Again, the direction of diffusion is not directed towards the opening of the hood.

6. The rated volume of air exhausted is not achieved because of large pressure loss as a result of accumulation of dust inside the air cleaning device.

7. A large volume of air finds its way into the duct system in some intermediate position (especially in the system up to the pull opening of the fan).

8. The volume of air and the static pressure of the fan becomes insufficient on account of subsequent addition of equipment and consequent addition of branch ducts.

9. Some obstacle is located very close to the hood.

10. The model of the hood itself is unsuited for the operation in question.

After ascertaining the presence of any of the above causes for the defect in the hood, the following modifications and steps should be adopted.

B. Modification of step for correcting the defect

The steps for setting right the defects discussed above will be discussed below in the same order.

1. When the insufficiency in the volume of air exhausted is only slight in degree, the defect can be set right by increasing the rotation speed of the fan slightly; of course if the motor used has the surplus capacity. However, if the insufficiency is of absolute nature, the fan should be replaced by one with the specified air exhausting capacity and static pressure. In the case of a fall in the volume of the air exhausted, the cause (slipping of the belt, wear and tear of the bearing, adherence of dust to the blades and the casing, and damage to the blades) should be ascertained.

2. The opening of the hood should be brought as close to the source of pollution as possible without interfering with the operation proper. If it is not possible to take this step, then flange should be provided to the hood in order to enlarge the zone of pull as far as possible.

3. The principal causes of accumulation of dust in the duct system can be traced to the insufficient carrying speed, or to the fall in carrying speed, or to the physical and chemical properties (like adhesion, charge acquiring property etc.) of the dust.

An insufficiency or a fall in the carrying speed can be rectified by adopting the step mentioned in Item 1 above; but if the insufficiency in carrying speed results from too large duct speed, then the duct diameter should be reduced by calculating backward from the volume of air exhausted so that the stipulated carrying speed is set up inside the duct. (Care should be taken here as the pressure loss will increase slightly).

4. Since the doors and the windows are left open during the summer, the mobility of air inside the room increases under the influence of the outside air. On the contrary, the mobility decreases to minimum during the winter as the doors and the windows are kept closed.

When the pull effect decreases under the influence of the outside air, the direction of the air current should be determined and no action need be taken if the opening of the hood happens to be at right angles to the direction of the air current. However, if the air current comes from the back or the side of the hood opening, then buffers should be erected around the hood for controlling the air current around the hood opening and the source.

5. When the dispersion speed is large, the procedure of operation should be modified for reducing this speed of dispersion as much as possible. However, if such a step is not possible, then the hood opening should be located as close to the contaminant source as possible and the hood should be provided with flange so that there is an increase in the control air speed in the dispersion limit zone.

When the hood opening does not face the direction of dispersion correctly, the facing of the hood opening should be adjusted so that the major part of the dispersing contaminants find their way into the hood opening under the force of their own inertia.

6. Especially in the case of the filter type devices, there occurs a considerable increase in the pressure loss and a consequent lowering in the volume of air exhausted as a result of the accumulation of dust.

This should be prevented as follows. A static pressure measurement hole should be opened in the duct on the pull side, and this hole should be connected to a U-tube, where the pressure loss in the air cleaning device should be checked regularly. When the pressure loss increases to 1.5 times the value of that observed at the time of installation, the device should be cleaned. However, some of the air cleaning devices are provided with automatic cleaning mechanism.

7. The pull effect of the hood is affected adversely if a large volume of air flows into the duct through the joints or cracks. Hence, these should be repaired without any delay.

In devices with especially long duct system or with large resistance in some intermediate point, the leakage in the vicinity of the pull opening of the fan should, sometimes, not be overlooked when seen from the angle of the amount of inflowing air, although the leakage may happen to be very small.

8. Providing new branch ducts does not pose any problem when there is enough surplus capacity in the static pressure and the volume of air of the fan. But in common practice, an increase in the branch duct brings about a decrease in the volume of air exhausted by the branch ducts already present, which in turn results in a decrease in the air exhausting effect of the hood. In such cases, the fan should be replaced by one which will be capable to produce the desired volume of air exhausted and the static pressure.

9. When there is an obstruction very close to the hood, the streamlines get disturbed and the contaminants escape

outside the streamlines. Again, the volume of pull air decreases due to the increase in the resistance, and such a situation leads to immediate escape of the contaminants outside the hood.

10. Usually there are specific models of hood suitable for specific operations. It is a great mistake to overlook this vital point and assume arbitrarily that any type of hood will do so long it is a hood. This is a point which needs special attention in designing the local air exhaust device

The hoods classified on the basis of their relative position with respect to the source of contaminant and the state of generation and dispersion of the contaminant have been shown in Table 5, and the sketches of the hoods have been shown in Fig. 3.

(ii) Duct

A careful observation of the duct from the outside can detect defects like subsidence, damage (wear and tear, holes caused by corrosion, and man-made damage etc.) loose joints (flange, soldering etc.), and accumulation of dust (when tapped lightly, a dull sound is produced in case there is accumulation of dust) etc.

Again, in internal inspection, the speed of the carrying current inside the duct is checked. The following instruments are used in measuring the speed of the carrying current. (i) Pilot tube, (ii) Biram windmill anemometer, and (iii) hot wire type anemometer.

A. Causes of the defect and the steps for rectification

The causes of defects in the duct system and the principal steps for rectification have been given in Table 6 below.

(iii) Air cleaning Device

Even though the hood may be of excellent performance inasmuch as it sucks in the contaminant generated completely, yet the contaminant will find its way into the atmosphere through

TABLE 5

Classification of hoods

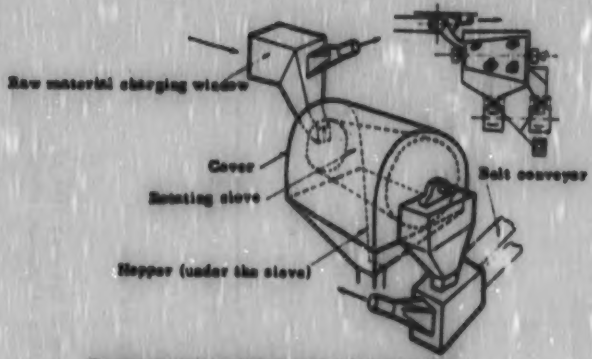
Model		Direction of the hood opening	Symbol	Operation for which the hood is suited
Enclosure type (E)	Cover model (E)	Upward (U) Lateral (L)	EE	Crushing, mesh preparation, machine tools, shifting, and storage tank, etc.
	Glove box model (X)	Upward (U) Lateral (L)	EX	Handling the isotopes and poisonous gases.
Booth type	Draft chamber model (D)	Lateral (L)	BD	Grinding, packing, chemical analysis and tests, handling the isotopes.
	Architectural booth model (B)		BB	Acid bath, spray painting
Outside fitting type (O)	Slot type (S)	Lateral (L)	OS	Cleaning the plating, dissolving, mesh preparation, spray painting, removing sand from the castings.
	Lever model (L)	Lateral (L)	OL	Removing sand from the castings.
	Grid model (G)	Downward (D)	OG	Painting, crushing, mould brushing.
	Circular model (O)	Upward (U) Lateral (L)	OO	Dissolving, shifting, crushing, welding, wood working machines.
	Rectangular model (R)	Upward (U) Lateral (L)	OR	Dissolving, shifting, crushing, welding, wood working machines.
Receiver type (R)	Canopy model (C)	Upward (U)	RC	Furnace, tempering, forging, welding.
	Circular model (O)	Lateral (L)	RO	Grinding.
	Rectangular model (R)	Lateral (L)	RR	Grinding.
	Cover model (Grinder model) (E)	Upward (U) Lateral (L) Downward (D)	RE	Table mounted grinder, furnace

Note: In case there is a necessity to indicate the direction of exhaust, and the symbol of the direction of exhaust is used together with that of the model, then the symbol for the direction of exhaust should precede that of the model. For example,

Upward, outside fitting type circular model: UOO

Downward, receiver type cover model: DRE

The enclosure type hood encloses the source of generation of the contaminants, and here the openings for charging the raw materials and observation etc. constitute the air inlet. The hood effect is maximum here.


Raw material charging window
Cover
Rotating sieve
Hopper (under the sieve)
Belt conveyor

Processes and operations where it can be used:

1. Shifting with the help of a sieve machine.
2. Crushing with the help of a crushing machine.
3. Mixing with the help of a mixing machine.
4. Stirring and churning with a stirrer.
5. Transportation with the help of conveyor.
6. Others (operations carried out with the machines which produce dust).

Fig. 3-1. Example of enclosure type (cover model) hood.

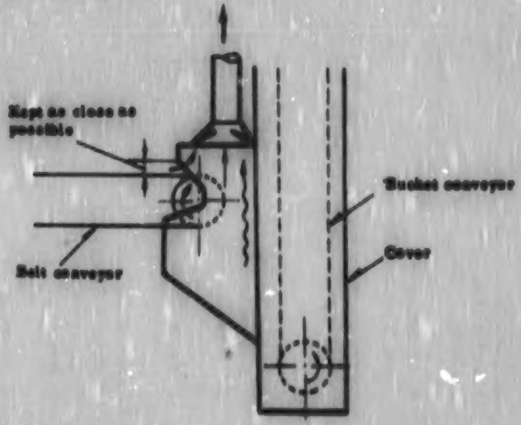

Kept as close as possible
Bucket conveyor
Cover
Belt conveyor

Fig. 3-2. Example of hood installed at the place where the bucket conveyor is loaded during the conveyor transportation operation.

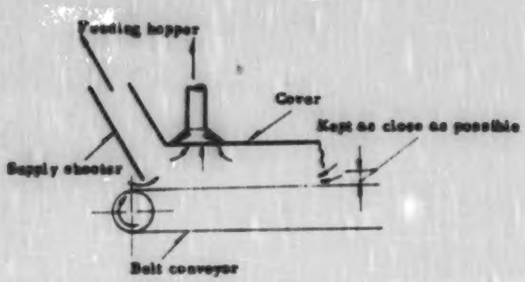
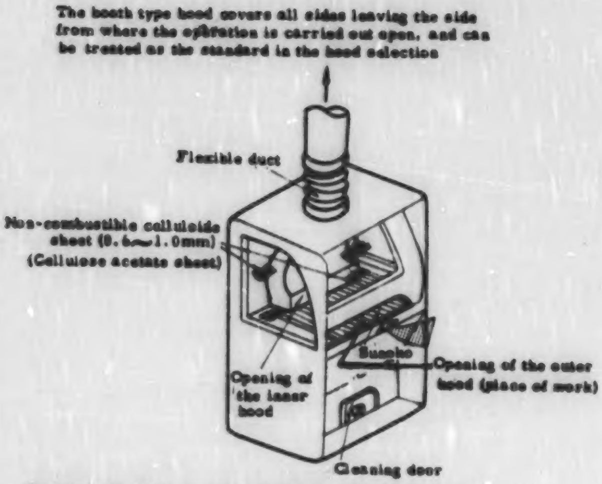

Feeding hopper
Cover
Kept as close as possible
Supply shooter
Belt conveyor

Fig. 3-3. Example of hood installed at the place where the belt conveyor is loaded from the hopper in the transportation operation using conveyor.

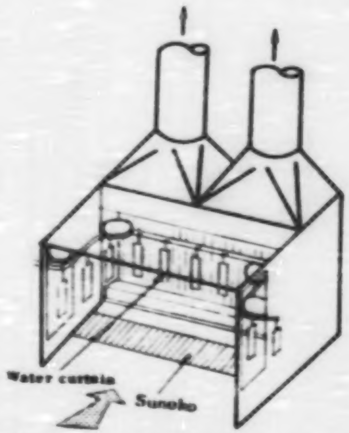

The booth type hood covers all sides leaving the side from where the operation is carried out open, and can be treated as the standard in the hood selection
Flexible duct
Non-combustible celluloide sheet (0.6~1.0mm) (Cellulose acetate sheet)
Sunoko
Opening of the outer hood (place of work)
Opening of the inner hood
Cleaning door

Grinding operation carried out with the sand blast machine

Operations where this hood can be used:
1. Grinding with the help of sand blasting machine
2. Chemical analysis
3. Others (Handling harmful substances etc.)

Fig. 3-4. Example of booth type (draft chamber model) hood.

The booth type architectural booth model hood covers the source of pollution from all sides leaving only one side open for carrying out the operation. As this open side is subjected to the pull air current, the hood effect is much greater here compared to the outside fitted type hoods



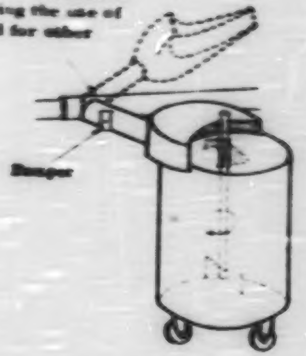
Spray painting operation carried out with the help of spray gun

Operations where the hood can be used:
1. Spray painting with the help of spray gun
2. Grinding with the help of swing grinder
3. Removing sand from the castings
4. Others (operations where the operator moves about over a space of about 1～2 m)

Fig. 3-5. Example of booth type architectural booth model hood.

Outside fitted type hood is selected where enclosed type or booth type hood cannot be installed because of the nature of the work. It is installed independent of the source of the contaminant.
Note: If the hood effect decreases due to the peripheral turbulent current, then baffles should be erected

The confluence with the main duct is of flexible type (thus enables to raise the hood when the operation stops thereby allowing the use of the space thus freed for other purposes)

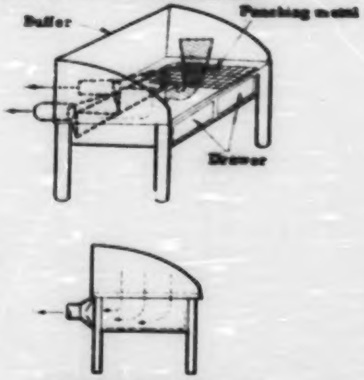


Mixing operation

Operations where this hood can be used:
Processes or operations where installation of enclosed type or booth type hood becomes technically difficult

Fig. 3-6. Example of outside fitted type (rectangular model) hood.

The opening in the outside fitted type grid model hood is provided at the bottom so that the dispersing gas or vapor or dust easily finds its way into the hood. So the dust is captured here with minimum energy (control current speed) and then carried into the hood



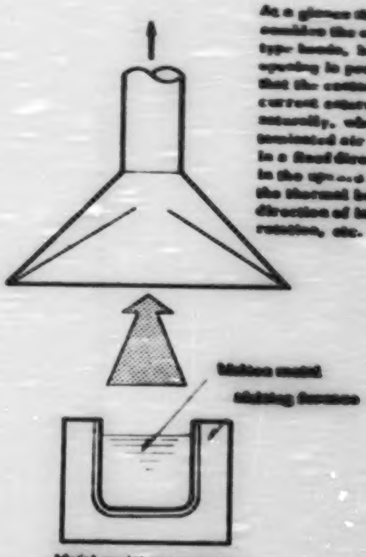
Type distribution operation

Operations where this hood can be used:

1. Type distribution operation.
2. Grinding with metal file
3. Removing sand from the castings with the shake out machine
4. Others (when the gas or vapor or dust produced can be removed effectively from the bottom)

Fig. 3-7 Example of outside fitted type grid model hood.

As a glance this model resembles the outside fitted type hoods, but here the opening is provided such that the contaminated air current enters into it naturally, when the contaminated air current flows in a fixed direction,for example, in the upward direction due to the thermal buoyancy or in the direction of inertia due to rotation, etc.



Metal melting operation

Operations where the hood can be used:

1. Melting operation carried out with the help of a furnace
2. Others (Operations where an upward current is produced due to thermal buoyancy)

Fig. 3-8. Example of Receiver type (canopy model) hood.

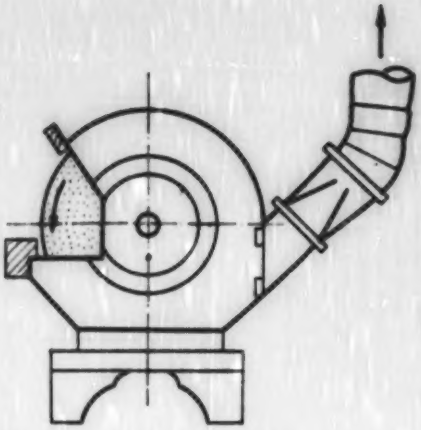
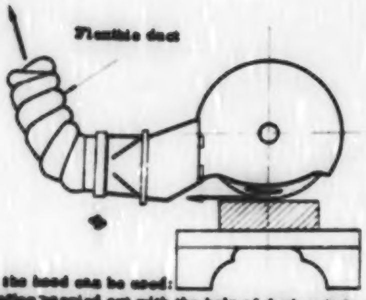


Fig. 3-9. An example of hood provided on desk grinder.



Operations where the hood can be used:

1. Grinding operation carried out with the help of desk grinder
2. Milling carried out with planer-type milling machine
3. Others (Grinding carried out with rotating brush machine etc.)

Fig. 3-10. An example of hood provided on planer -type milling machine.

TABLE 6

Phenomenon	Cause	Steps of rectification
Subsidence	1. Shocks at the time of installation 2. High internal negative pressure	1. Proper care should be taken at the time of installation to avoid any type of shock. 2. Either the sheet thickness of the duct is increased, or if the shape is rectangular it is changed to circular. 3. Reinforced with the help of angles.
Damage	1. Wear and tear 2. Corrosion 3. Man-made damages (striking with hammer or some other thing)	1. Because wear and tear mainly affects the bends, material above 1 or 2 count should be used. 2. Either corrosion resistant material should be used, or anti-corrosion paint should be applied. 3. Even when dust accumulates, the duct should not be struck with hammer. A cleaning door should be provided for removing the dust.
Loose joint	1. Nuts not tightened due to negligence 2. Loosening of nuts and falling off of the solder due to vibration 3. Caving in due to the weight of the dust accumulated	1. The whole circumference should be investigated and any loose nut should be tightened properly. 2. These occur more often near the fan inlet. To check these, the spring washer is used, and the solder is poured into the deep interior. 3. The duct support should be strengthened so that stress is not produced on the joints.
Accumulation of dust	1. Lowering in the speed of the carrying air current 2. Physical and chemical properties of the dust etc.	1. Inspection and cleaning should be carried out periodically allowing no scope for the dust to accumulate inside the duct.,

the exhaust outlet provided the performance of the air cleaning device, whose function is to remove the contaminant, is poor. Such a situation poses the danger of not only contaminating the working environment inside the enterprise once again, but also of causing local hazard if the contaminant spreads in the locality. Consequently, periodic check-up of the air cleaning device is of paramount importance. The sections where special attention should be paid during the periodic check-ups are given below.

a) Cyclone

1. Whether holes have appeared in the cylindrical upper section and in the tapered lower section due to friction.

2. Whether air flows in through the dust chamber and the dust push outlet.

3. Whether there is any projection or unevenness inside the cyclone that affects the air current.

4. Whether dust has accumulated in the tapered lower section.

5. Whether the dust chamber has become full of dust.

b) Bag Filter

1. Whether hole has appeared in the filter cloth.

2. Whether the part of the cloth filter where it is fixed is loose or torn.

3. Whether air is leaking in through the dust chamber and the dust removing opening.

4. Whether the dust chamber has been filled by dust.

5. Whether the filter cloth has been clogged completely.

c) Venturi Scrapper

1. Whether dust has adhered and accumulated on the inner wall.

2. Whether the specified amount of cleaning water is sprayed, and whether the spray is uniform.

3. Detecting corroded spots.

A. Rectifying the Defective Spots

If the defects mentioned above are detected in the air cleaning device, these should be rectified immediately. Again, static pressure holes should be provided before and after the air cleaning device and U-tubes made of vinyl or rubber should be fitted there so that these serve as permanent attachments in order to know the defective spot in the air cleaning device and also to know whether the device is working properly or not.

The increase or decrease in the pressure difference in the U-tube gives an instantaneous clue as to whether there is any abnormality or not.

Since the point discussed above is equally applicable to the duct system, providing U-tube in the duct system is of great importance.

It is a common practice at present to provide a prefilter with collection efficiency much lower than the air cleaning device for removing the coarse contaminants beforehand in order to reduce the load on the performance of the air cleaning device.

iv) Fan

The most effective way to prevent the wear and tear of the fan blades and adherence of dust on them is to provide the fan behind the air cleaning device. Since the fan will suck in relatively clean air in such case, the wear and tear of the fan blades as well as adherence of dust on the blades will decrease greatly.

a) Fan used for handling air contaminated with dust

The inner walls of the casing, where the duct comes in contact with the fan blades, is provided with lining in order to protect the blades and the casing from wear and tear.

This step is very simple and is also adopted most widely. However, the lining cannot be provided in high speed fans as the strength of lining proves to be a limitation. In such cases the blades should be treated as expendable parts, and hence the fans should be designed carefully with the provision of interchangeable blades. (Usually, radial fans are used here).

b) Fan used for handling corrosive gas

Here either the fan should be made from anti-corrosion material, or the fan should be coated with some anti-corrosion film. The step selected depends upon the temperature of the gas and the concentration of dust. (Here usually turbo fan or radial fan is used).

c) Fan used for handling high temperature gas

The properties of the metals deteriorate with the rise in temperature; and the higher the temperature, the greater is the degree of deterioration.

Consequently, in designing the fans to be used for handling high temperature gas, the ceiling temperature of the pull gas should be determined very accurately in order to make provisions to avoid any unexpected deformity or accident.

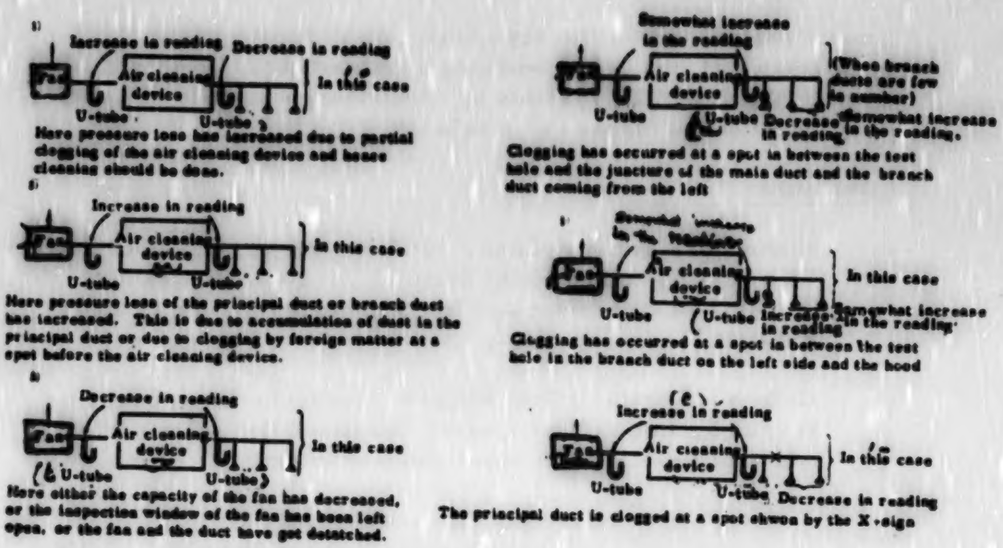
Wear and tear and deformity of the blades, expansion of the shaft and burning of the bearing etc. are some of the effects of the high temperature gas. (Here usually radial fan, turbo fan or multi-blade fan is used).

3) Inspection with the help of U-tube

As has been stated already, U-tube should be provided at important spots in the local exhaust device and the static pressure shown in these tubes should be monitored constantly for knowing any defect; and in case some abnormality is detected, proper rectification should be carried out immediately. (vide Fig. 4).

IV. Conclusion

More than ten years ago the author was engaged in the work of environmental hygiene in a health center in the hills in


Increase in reading
Decrease in reading
Fan
Air cleaning device
U-tube
U-tube
In this case
Increase in reading
Fan
Air cleaning device
U-tube
U-tube
In this case
Decrease in reading
Fan
Air cleaning device
U-tube
U-tube
In this case
Somewhat increase in the reading
Fan
Air cleaning device
(When branch ducts are few in number)
U-tube
U-tube
Decrease in reading
Somewhat increase in the reading.
Fan
Air cleaning device
In this case
U-tube
U-tube
Increase in reading
Somewhat increase in the reading
Increase in reading
Fan
Air cleaning device
In this case
U-tube
U-tube
Decrease in reading

Here pressure loss has increased due to partial clogging of the air cleaning device and hence cleaning should be done.

Here pressure loss of the principal duct or branch duct has increased. This is due to accumulation of dust in the principal duct or due to clogging by foreign matter at a spot before the air cleaning device.

Here either the capacity of the fan has decreased, or the inspection window of the fan has been left open, or the fan and the duct have got detatched.

Clogging has occurred at a spot in between the test hole and the juncture of the main duct and the branch duct coming from the left

Clogging has occurred at a spot in between the test hole in the branch duct on the left side and the hood

The principal duct is clogged at a spot shwon by the X-sign

Fig. 4. Knowing defective spots in the duct system by static pressure measurement.

interior Hokkaido with a view to improving the environmental conditions in the inns and recouperation centers. At that time the farmers in the newly opened up virgin lands quite often came for advice on building cold-proof house. Although most of the farmers at that time used long stove, yet open-type heating places were also not rare although these emitted a lot of smoke which filled the rooms. Naturally most of the farmers and their wives and children suffered from trachoma caused by smoke (because of rubbing of eyes with dirty hands). These people showed keen interest in the advice given by the lady health assistants who accompanied the author during such trips. The author also advised the farmers to instal stoves so that the smoke emitted could be exhausted in the atmosphere outside the house, through the chimney.

A few years later the clear blue sky and the clean water of the district towns started showing signs of contamination. This was the inevitable outcome of ever-increasing industrialization of the district towns. The author is engaged, at present, in evolving engineering steps for checking the injurious gas, vapor and dust, which are generated in the environment where the workers work. The author believes that the most urgent question at present is the popularization of local exhaust system by providing stoves in the working environment. Only by this simple step it will be possible to save a large number of people from the dreaded disease of trachoma.

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HOSPITAL INFECTION

Y. KANEKO & T. MURATA

The social life of the human race is standing on a cross-road today under the impact of everincreasing pace of industrialization. Communal living by a large number of people living in a relatively congested environment, which had been a characteristic feature in the hospitals, so far, is becoming an essential feature of the social life as well with the growing urbanization, construction of multistorey apartments and mammoth buildings accommodating tens of thousands of people. In spite of such a crowded living condition, the problem of large scale infection occurs only rarely, and the victims too being restricted to the kindergarten and primary school children in most of the cases. Hence, a question naturally arises why always the hospitals become the main target of infection.

I. Characteristic Features of the Hospitals

Firstly, the hospitals not only provide the ideal ground for accumulation of the so-called hospital bacteria, the micro-organisms with remarkable resistance to the chemicals and medicines and thus proving very difficult to be supressed, but also provide the meeting place for people suffering from all sorts of ailments. These diseased people harbour the harmful germs in a very high concentration and they release these freely in the environment. Although the healthy individuals also harbour diverse microorganisms and release a large number of these in the environment, yet these are not as dangerous as those released by the diseased individuals insofar as the quality and quantity are concerned. In recent years, staphylococcus, bacillus pyocyanous and streptococcus have started attracting more and more attention as the organisms primarily responsible for infection within the hospitals. Although, even the healthy human beings carry all these microorganisms, yet those found in the diseased individuals differ not only qualitatively and quantitatively, but even their route of release into the environment differs from that of the healthy individuals.

Secondly, as against the assembly of the highly resistant microorganisms as mentioned above, the hospitals are the meeting places of people who have lost their capacity to resist infection to a considerable extent. The hospitals indeed accommodate the people of all ages from newborn babies to old people suffering from cancer and other ailments, including young people having the same problem or other due to illness.

II. Mechanism of Infection and Problems Involved in the Working of the Hospitals

It is needless to say that new infections occur through the course: source of infection → route of infection → person susceptible to infection: and that no infection is possible if any one of the above three happens to be missing. Consequently in devising counter steps, the question arises as to which one of the above three should form the focus of the preventive measure. The relative importance of the three varies depending upon the type of infection involved. In air conditioning, the route of infection forms the principal target, but air conditioning alone is not enough for checking infection. What becomes important here is that the hospital authorities on their part should take vigorous and positive steps simultaneously for controlling the source of infection and improving the general condition of the people susceptible to infection.

A typical and traditional step against the source of infection can be seen in the conventional isolation hospital. However, the main problem in the hospital infection does not involve the patients admitted in the conventional isolation hospitals. For example, in the case of surgery, the patients undergoing operation for cancer can be treated as rather clean patients. However, the reality is that the patients developing suppuration due to external injury also receive the same surgical treatment. Again, the patients suffering from burns and for whom suppuration is most dangerous are also treated as surgeons speciality.

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Pediatrics constitute the typical case when it comes to the question of children susceptible to infection. Among the children there are many who have not suffered from various types of infectious diseases of acute type, and hence they lack the immunity against these diseases. Hence, it is quite natural that the children admitted in children hospital catch new infection readily on account of the relatively crowded living condition. Again in the field of neurology, where infection does not constitute any important feature, there occurs mass outbreak of dysentry occasionally in the mental hospitals; and there is nothing unnatural in such outbreaks as the hygienic sense of a normal person cannot be expected from a person suffering from mental illness. As the dysentry in such cases is supposed to be of contact origin, seggregating the patients in small groups and providing separate lavatories to separate groups can cut down the incidence drastically.

One of the problems of hospital infection lies in the conventional pattern of division in the hospitals like medical ward, surgical ward and gynaecology and obstetrics ward etc., whose origin can be found in the history of development of therapeutics. Such division creates problems not only in the general hospitals, but in the specialised hospitals as well. Even in the same therapeutic category, there are patients who are suffering from infection from the very beginning as well as there are patients for whom infection means further complication. In spite of such a situation all these patients are put together without any discrimination so long they fall in the category of same therapeutic division. Probably here lies the greatest problem in the present day hospital designing. It is essential that clean section and infection section should be provided in each therapeutic division. The rapid decrease in the legally defined contageous disease patients has trigerred off a process of rethinking on the significance of seggregation as a step to counter the spread of the infectious disease at present. Indeed it seems that the time has come when the large hospitals should think in terms of erecting infection wards which will also cater to the needs of the legally defined contageous disease patients. Again, in designing the air conditioning of the hospitals, proper provisions should be made for the various types of zones suitable for specific needs.

III. Types of Hospital Infection

The discussion above has been based upon the consideration that the source of infection lies in a third person other than the person susceptible to the infection. In other words, it is the infection received from the other side, whereas in the case of within-the-hospital infection it is the case of same side infection. As has been stated above, even the healthy individuals are the depots of microorganisms, and staphylococcus can be detected in their nose, skin and handkerchief. The bacillus pyocyanous can be detected in the excreta of any healthy person. In the case of streptococcus, the author has found this germ in the throat of scores of primary school children out of every hundred investigated, especially during the winter. In case it is assumed that the healthy individuals provide good breeding ground for the microorganisms after catching infection from some source, then they in turn become the source of infection. Quite often the patients develop high fever with the symptoms of hematomycosis while being administered with intravenus nutrition. In all probability here the bacteria enter into the system from the skin.

In this way it is possible to guess whether the infection is from the other side or from the same side on the basis of a study of the variety of the staphylococcus, bacillus pyocyanous and streptococcus. As the germs causing infection in the hospitals are normally present in our living environment, proper classification of the varieties will be very advantageous in locating the source of the hospital infection. The staphylococcus can be divided into various varieties even according to the phage-type, although in some cases no division can be made. Again, according to the coagulase-type there are 7 varieties. The bacillus pyocyanous has 12 varieties at present, and the streptococcus has more than 50 varieties.

IV. Route by which the Source of Infection Enters the Hospital

The infection can enter the hospital via a number of routes, such as

1) Patients already suffering from the infection or passing through the incubation period.

2) Employees suffering from the infection.

3) Persons coming for visiting.

4) Infection carried by food and drinks.

In the case of animals used in experiments, it is the normal practice to have a quarantine period during which the animals are seggregated in separate rooms for making sure that these do not carry the infection from outside. However, it is extremly difficult to have such a system for the human beings. In the case of the employees, the only steps taken are periodical checkup of health, and depending upon the finding, the employees concerned are given medical leave for treatment, or they are allotted alternative place of work. That infection is relatively higher in proportion among the hospital employees has also been corroborated by a number of reports published on the subject, and it is well-known that the students of nursing school show a higher incidence of infection compared to the students of the girls colleges in the same age group.

Visitors create problem for the new born infant and children wards. When children come for visiting together with the parents, they should never be admitted. Because they are the most likely carriers of the infection.

Quite often infection occurs through the medium of food or drink. The four walls of the hospital constitute the main object of hygiene control in the hospitals, and the food manufacturers are left out of consideration. This is one of the main defects in the present day hygiene control in the hospitals.

V. Mode of Spread of Infection inside the Hospital

Next, the question arises about the way the infection which penetrates the hospital spreads within the hospital.

The first and foremost carrier is the human beings. Here the infection spreads through human contact, and an extreme example has been shown in Table 1. The hands and the fingers of the dysentry patients are usually full of the dysentry germs, which migrate there during the cleaning of the anal region. Again, infection spreads rapidly among the kindergarten children through the contact of hand when they play marry-go-round holding each other's hand. A typical example of infection by contact is the sex diseases, and indirect infection can occur through the medium of the medical implements. The latter can however be eliminated by adopting proper technological steps.

Next in order comes the question of aerial propagation of infection. The three major mediums here are the droplets, droplet nuclei and dust.

The droplets find their way directly into the conjunctiva, oral cavity, skin and open wound. As the droplets have considerable weight, it seems that they are incapable of floating about freely in the air. However, they can fly to a considerable distance due to sneezing or blowing of nose. Table 2 shows a typical example of this. This study has been carried out in a primary school, and not in a hospital, with two sections of the third year students in a primary school, over a period of 10 months from June to March 1960. Here a track was kept of the carriers of dyptheria germs by taking samples from the threat of the students once a month and cultivating them over the above period. Each class had about 45 students, and among them ten and eleven students respectively of the two classes were found to harbour the dyptheria germs as shown in the table. Such high incidence is unlikely at present as the disease has declined to the minimum, but the above can be taken as a typical picture of the early years of the sixties. In the table, the symbols G, M and I represent the strains of the dyptheria germ. It is interesting to note that the G strain was confined to the Section 3 and could not be detected in Section 4. These two classes were located in adjacent rooms, and the children of the two classes played together during the recess period. The findings of the study clearly shows that this extent of contact is too inadequate for the spread of the dyptheria germ from child to child. It seems that staying together in the same room over a certain number of hours every day plays a more dominant role in the spread of the infection. Similar results have been observed with streptococcus (germ of scarlet fever), but in this case the germ could not be found in the samples of the precipitated bacteria taken from the

TABLE 1

Contamination of the anal region and the hands and the fingers of the dysentry patients
(Manji Byoin Hospital, 1953)

	Contamination of anal region			Contamination of hands and fingers		
	No. of cases	Positive	%	No. of cases	Positive	%
Before passing the excreta	21	16	76.2	55	6	10.9
After passing the excreta		20	95.2		22	42.0

floor. Hence these can be taken as the typical cases of infection by droplets. Again, it has been reported that lending or borrowing of pencils has been forbidden among the primary school students in the foreign countries with a view to stopping the spread of dyptheria. In short, an infected person apparently contaminates his immediate environment through the medium of the droplets.

TABLE 2

Diptheria germ carriers among the primary school children
(1970, Kawasaki City)

Month	Section 3										Section 4										
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11
June					I	I			G												
July			I																		
August																					
September					I												M		M		
October																					
November				G	I						M			M					M		
December				G	G						M			M		M		M			
January							G	G	M				M			■		M		M	M
February							G					M	M		M			M	M	M	M
March	G	I		G						I								I		I	

The authors agree to the view of the Sub-committee for the Evaluation of Methods to Control Air-borne Infections, of the Committee on Research and Standards (1947) of the United States that the droplets should be treated as a major source of infection by contact.

Third in order, as carrier, comes the droplet nuclei. Here the droplets get air-borne after getting dried up and consequently becoming lighter, and these air-borne nuclei get into the human system through breathing. The order of the dust as a potential source of carrier comes next. Here the things coming out of the body of the patients initially get attached to the floor, dress and bed sheet etc. and from there get air borne together with dust at an appropriate time. These move higher up with the movement of the human beings and get into the system again through breathing.

The last two mentioned above are the carriers which should be taken into consideration while planning air conditioning.

VI. Air Conditioning as Seen from the Angle of Infection within the Hospital

The main problem that involves air conditioning, when viewed from the angle of prevention of within-the-hospital infection, is the question of reducing the effect of crowding as a step to check the microorganisms, leaving the physical conditions involving air conditioning out of consideration. It is impossible to sterilize the environment in which we live and work, and there is no necessity for it either. Just keeping the environment in a state as it exists in normal nature is enough. Considering from the weakening physical resistance of the patients who enter the hospital, it is necessary to keep the environment in a state much superior to that found in ordinary nature. This is especially true for the surgical operation theater.

The three main steps that can be thought of for reducing the effects of crowding are (a) diluting the contaminated air by changing the air, (b) introducing germicidal steps, and (c) disposal of the droplet nuclei and dust.

However, the answer cannot be found in a single centralized system covering the whole hospital because the hospital can be divided into a number of zones each used for a specific purpose. Furthermore, the hospitals accommodates people of all ages, from those who are very old to the new-born babies, as well as people who are seriously ill to those who are almost cured and normal. The picture becomes all the more complex when the question of hospital employees moving all over is also taken into consideration. In the opinion of the authors, any step that is devised should satisfy all the most desirable conditions for each zone inclusive of the specific wards located therein. The authors will discuss below this point for reference by quoting from the study they had carried out sometimes back on 'A Study of the Contamination of Air by Actual Measurement and On the Basis of Available Literature for Preventing Within the Hospital Infection' a study entrusted by the Japan National Railways, and the findings of which have been reported to the 38th Annual Meeting for Reporting the Academic Researches of the Kanto Regional Branch of the Japan Association of Architects (Nihon Kenchiku Gakkai Kanto Shibu Dai 38 Kai Gakujutsu Kenkyū Happyō Kai) held in 1967.

VII. Resistance of the Microorganisms causing Infection within the Hospitals and the Fan Coil Unit

A fixed amount each of Yorenkin, staphylococcus and bacillus pyocyaneus was transferred on sterilized filter paper (size: 10 x 30 mm) and kept at the temperatures of 4°C, 25°C and 70°C under the condition of natural drying. The number of bacteria surviving were determined with the passing of time. The results have been shown in Table 3 below.

Since the bacteria are supposed to be present in human secretion in the form of drops or droplets or dust, the above experiment was conducted using both the raw biological salt solution as well as the biological salt solution containing 0.05% mucin. In both the cases the bacteria population fell conspicuously after 10 min at 70°C. However, the bacteria population showed varying degree of decline at 4°C and 25°C with the passing of time. It seems that the solution containing mucin probably gives a picture very close to that found in nature.

In the case of the mucin solution, the bacteria survives to a considerable extent at 4°C. At 25°C, the survival ratio falls gradually although the sampling error is higher here. That the

TABLE 3

Experiment on the survival of the staphylococcus, bacillus pyocyanus and γ-Yorenkin at the temperatures of 4°C, 25°C and 70°C

Medium	Temp.	Type of bacteria	[illegible]	After 10 min	After 20 min	After 4 hours	After 8 hours	After 12 hours	After 24 hours
Biological salt solution	4 °C	Staphylococcus	3900			1900	2200	3000	210
		Bacillus pyocyanus	1900			1200	900	57	130
		Yorenkin	4200			8800	5800	2800	600
	25 °C	.	-do-			2	3	14	–
		.				64	28	3	1
		.				100(–)	100(–)	100(–)	–
	70 °C	.	-do-	10	–				
		.		190	–				
		.		10(–)	–				
Biological salt solution containing 0.05% mucin	4 °C	.	6700			2700	4000	1200	2900
		.	1100			1100	910	760	760
		.	7100			6500	6600	6100	3400
	25 °C	.				700	220	6	190
		.				190	530	510	250
		.				800	1500	1600	2
	70 °C	.		10(–)	–				
		.		10(–)	–				
		.		10(–)	–				

Note 1) The sign (-) means that the culture is negative in the original solution. 10(-) means that a single colony turns into 10 colonies and negative.

2) In this experiment, a fixed amount each of the bacteria was transferred to the filter papers (size: about 1x3 cm) sterilized by dry heating, and the specimens were kept under the condition of natural drying.

survival ratio is highest at 4°C can be attributed to the fact that this falls in the microbiological zone for the bacteria concerned.

Next, dysentry germs were kept on various substances and left for 24 hours under the condition of 29% humidity during the day time and 20% humidity during the night time, following which the survival ratio was determined. The results in terms of percentage have been shown in Table 4. In the figure, the population of living bacteria at -20°C can be taken as the starting bacteria population in all the cases. The results show that the nature of the substance as well as the temperature have a great say on the survival ratio of the dysentry germs.

Fig. 1 shows the vicissitude of the staphylococcus population when kept on the fan of the fan coil unit. Since the fan coil

TABLE 4

Effect of temperature on the survival ratio (percentage) of the dysentry germs when kept on various substances for 24 hours

	Glass	Cotton	Wood	Aluminum	Filter paper
20	28.6	29.7	41.7	21.3	30.8
4	5.7	26.9	19.4	10.3	23.4
15	8.2	22.3	19.0	4.8	12.7
37	2.7	8.2	8.6	1.4	3.5
45	0.0	0.0	0.2	0.0	0.3

(J. Hyg., 60. 1. 35. 1962)

unit recirculates the indoor air, there is a hypothesis that there is a possibility of multiplication of the bacteria which happen to get captured on the fan. Fixed amounts of yellow staphylococcus which is considered to be pathogenic, and epidermic staphylococcus which is considered to be non-pathogenic were transferred to sterilized filter papers and then these papers were attached to the fan, following which the fan coil unit was put into operation. Next the filter papers were taken out at fixed intervals and the bacteria population was counted. Here the room temperature was around 24°~26°C, and the fan temperature was 4.5°C showing the state of frosting. From the figure it will be seen that the bacteria population on the fan decreased considerably after 8 hours at 16.50 P.M. even at 4.5°C. Following this the fan was allowed to warm up to room temperature after stopping cooling, and the decline in the bacteria population continued at a rather accelerated pace. The bacteria population practically vanished after about 24 hours at 8.50 A.M. These results are very suggestive when seen in the light of the results shown in Table 3. Whereas the bacteria population remains fairly constant after 8 hours at 4°C according to Table 3, in Fig. 1 it is seen that the population decreases from $10^8 \sim 10^5$ after 8 hours at 4.5°C. As it is generally assumed that the difference in population for 0.5°C is not significant in this temperature range, the difference in the two findings can probably be attributed to the washing away of the bacteria by water which collected on the fan as frost. Unfortunately no attempt was made here to trace the bacteria in the drain, but even then it is very likely that the bacteria had indeed been washed away by the melting frosted water.

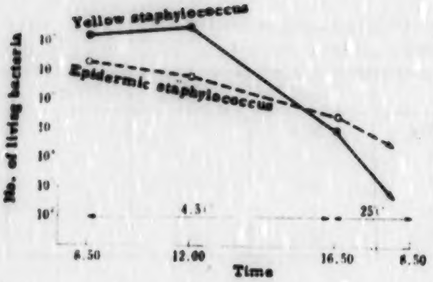

Fig. 1. Vicissitude of the staphylococcus population on the fan of the fan coil unit.

From the above results it seems that the fan coil unit accumulates the aerial bacteria during cooling, which is next washed away as the frost on the fan melts down. Thus, the effect is somewhat that of a filter. This suggests the necessity of extending the hygienic measures to the drains as well. Again, in case hot water of 70°~80°C is passed through the fan coil unit for warming the room, then, although it is not clearly known as to how long the aerial bacteria are exposed to this temperature, yet considering from the results of Table 3, it seems that the bacteria dies in a very short time under the influence of temperature. Thus, the fan coil unit discharges the function of capturing the aerial bacteria and then either washing them away or killing them depending upon whether cooling or heating is carried out.

Generally speaking, certain fixed temperature conditions (with a wide range) and nutrition are essential for the multiplication of the microorganisms. Again, the nutrients should be in a dissolved state so that the microorganisms can absorb these. Of course, the bacteria come in diverse types, some resistant and some weak to the dry environments. However, the bacteria responsible for hospital infection are usually weak to the dry ~~con~~ conditions. Thus, these bacteria create relatively lesser problems during the winter when heating is carried out. However, the germs of tuberculosis etc. which are usually found in the secretions of the patients turn into light droplet nuclei after getting dried up, ultimately ending up in the air conditioning system and getting circulated over and over again. Thus, it is desirable to divide the hospital into a number of zones while planning air conditioning, and care should be taken not to tag up these zones with the conventional clinical wards. At any rate, there are still many points in the mechanism of hospital infection that nee proper explanation. It is for the future research workers to throw adequate light on these points.

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